A Summary of Current Program and
Preliminary Report of Progress

OILSEEDS AND PEANUT RESEARCH

of the
United States Department of Agriculture
and cooperating agencies

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

There is included under each problem area in the report, a brief and very general statement on the nature of the research being conducted by the State Agricultural Experiment Stations and the professional manpower being devoted by the State stations to such research. Also included is a brief description of related work conducted by private organizations. No details on progress of State station or industry research are included except as such work is cooperative with U.S.D.A.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the last two years. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C.
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OTHER COMMODITY AND FUNCTIONAL REPORTS

A progress report similar to this one is prepared for use by each of the following research and marketing advisory committees:

Citrus and Subtropical Fruit
Cotton and Cottonseed
Dairy
Deciduous Fruit and Tree Nut
Forage, Feed and Seed
Forestry
Grain
Livestock
Potato
Poultry
Rice
Sugar
Sheep and Wool
Tobacco
Vegetable
Economics
Farm Equipment and Structures
Food and Nutrition
Food Distribution
Home Economics
Soils, Water and Fertilizer
Transportation and Storage

Two additional reports of progress are prepared in order to make available the complete research program. They are:

Ornamentals and Other Miscellaneous Commodities
Other Research -- Cross Commodity

ORGANIZATIONAL UNIT REPORTS

All of the material in the commodity and functional reports listed above is the same as that found in the 20 division and 3 service research reports listed below.

Agricultural Research Service (ARS)

Agricultural Engineering
Animal Disease & Parasite
Animal Husbandry
Crops
Entomology
Soil and Water Conservation
Utilization -- Eastern
Utilization -- Northern
Utilization -- Southern
Utilization -- Western
Human Nutrition
Clothing and Housing
Consumer & Food Economics

Agricultural Marketing Service (AMS)

Market Quality
Transportation & Facilities

Economic Research Service (ERS)

Farm Economics
Marketing Economics
Economic & Statistical Analysis
Foreign Development & Trade Analysis
Foreign Regional Analysis

Other Services

Farmer Cooperative Service (FCS)
Forest Service (FS)
Statistical Reporting Service (SRS)

A copy of this report or any of the others listed above may be requested from James F. Lankford, Executive Secretary, Oilseeds and Peanut Research and Marketing Advisory Committee, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

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V. HUMAN NUTRITION AND CONSUMER-USE RESEARCH

Introduction

This report deals with research on all kinds of oilseeds and peanuts. The report covers Farm Research, Utilization Research, Marketing Research, Economic Research, and Nutrition and Consumer-Use Research of the U.S.D.A. and cooperating agencies. Only a brief description of the related work of the State Experiment Stations and industry is included.

Under each of the Problem Areas there is a statement describing the Program of work under way and the professional man-years devoted to the major kinds of research included. The relative scope of the total research effort on oilseeds and peanuts is indicated by the approximate number of professional man-years employed; 221 by U.S.D.A., 54 by the State Experiment Stations and about 500 by industry and other organizations.

A brief report of Progress and significant findings for U.S.D.A. and cooperative programs is given for each phase of the program.

A considerable amount of basic cross-commodity and functional research that will supply new knowledge applicable to the oilseeds and peanut problems is not included in this report. Such research is included in the functional reports such as "Economics," "Soils, Water and Fertilizer," and in the "Other Research" report.

Research by USDA

The Farm Research comprises investigations on introduction, breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, and crop harvesting and handling operations and equipment. This research is conducted by the Crops, Soil and Water Conservation, Entomology and Agricultural Engineering Divisions of the Agricultural Research Service, and in Fiscal Year 1962 involved 61.2 professional man-years.

Utilization Research is concerned with improved methods and equipment for mill processing of oilseeds and peanuts, and development of new and improved food, feed, and industrial uses of peanut and oilseed products. The work is done at the Eastern Utilization Research and Development Division, Wyndmoor, Pennsylvania; Northern Utilization Research and Development Division, Peoria, Illinois; at the Southern Utilization Research and Development Division, New Orleans, Louisiana; at the Western Utilization Research and Development Division, Albany, California; and under contract with State and foreign country laboratories and in cooperation with the industry and other organizations mentioned under Program for each research area. In Fiscal Year 1962 the work involved 136.0 professional man-years.

Marketing Research involves the physical and biological aspects of assembly, packaging, transporting, storing and distribution from the time the product leaves the farm until it reaches the ultimate consumer. The work reported herein is conducted by the Market Quality and Transportation and Facilities Research Divisions of the Agricultural Marketing Service and utilized 9.8 professional man-years in Fiscal Year 1962.

Economic Research is concerned with marketing costs, margins and efficiency; market potential, supply and demand; outlook and situation; improving oilseeds and peanut estimates; and improving marketing through research with farmer cooperatives. The work reported herein is done by the Economic and Statistical Analysis and the Marketing Economics Research Divisions of the Economic Research Service; by the Standards and Research Division of the Statistical Reporting Service; and by the Marketing Division of the Farmer Cooperative Service. Approximately 10.7 professional man-years were devoted to this work in Fiscal Year 1962.

Nutrition and Consumer-use research pertains to composition and nutritive value; physiological availability of nutrients and their effects; and new and improved methods of preparation, preservation and care in homes, eating establishments and institutions. This work is done by the Divisions of Human Nutrition Research and Consumer and Food Economics Research of the Agricultural Research Service and in Fiscal Year 1962 involved 3.2 professional man-years.

Research by the State Experiment Stations

There is included under each problem area a brief and very general statement on the nature of the research being conducted by the State Agricultural Experiment Stations and the professional man-power being devoted by the State stations to such research.

Consolidating this information for the entire field of interest we find that in Fiscal Year 1962 a total of 54 professional man-years were spent by the State Agricultural Experiment Stations on oilseed and peanut research. No details on progress of State station research are included in this report except as such work is cooperative with U.S.D.A.

Oilseed and peanut research in 1962 was in progress in about half of the 53 State Agricultural Experiment Stations. Studies under way were carried out by research workers in departments of Agronomy and Soils, Botany and Plant Pathology, Entomology, Agricultural Engineering, Agricultural Economics, Chemistry and Food Technology, and Oilseed and Peanut Research at the State Agricultural Experiment Stations in 1962 included 12.7 professional man-years on breeding and genetics; 11.7 on culture; 5.9 on diseases; 4.5 on variety evaluation; and the remainder on insects; weed control; agricultural engineering; utilization, and economics. In addition, considerable related research was conducted on problems which could not readily be identified with specific commodities such as oilseed and peanuts.

Summary of Research by Industry and Other Organizations

The 500 professional man-years estimated as industry's participation in oilseed and peanut research are employed primarily by manufacturers of farm machinery and equipment, processors of intermediate products such as unrefined vegetable oils and by manufacturers of consumer products such as shortening, margarine and peanut butter.

An example of research by farm machinery manufacturers is hydraulic power equipment and tractors and related vehicles.

Industry cannot be expected to conduct basic work which is remote from its profit objectives. However, basic research done by the Department and States will be utilized by industrial research laboratories in further development of improved products and equipment. Industry's cooperation in supporting oilseed and peanut research at Federal and State Stations has contributed greatly to its success. Continued and expanded cooperation in the form of grants, loans of equipment and facilities is anticipated.

Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Through cooperative research with the Virginia and Georgia Experiment Stations and the Agricultural Engineering Research Division of Agricultural Research Service, a simple practical comparatively inexpensive procedure for controlling stem rot, or southern blight, of peanuts has been developed. Precision application and deep coverage of organic debris in initial land preparation and cultivation so that no soil is thrown around the base of the plants during their development effectively suppress stem rot and simultaneously increase yield and market grade of pods. No practical control for stem rot was known previously. Stem rot and disease complexes associated with it are estimated to have caused an average annual loss in production of peanuts of more than 10 percent during the past decade.

Much of the Crop's Div. research is directed toward improving crops by breeding. A few examples will illustrate the significance of this phase of the program. Over 80 percent of the approximately 6.6 million acres of soybeans harvested for beans in the Southern States in 1961 was planted to varieties released from the cooperative soybean-breeding program during the past 10 years. The variety 'Lee', resistant to several diseases prevalent in the area, was planted on approximately 55 percent of the total acreage in the United States and on over 70 percent of the acreage in States where its maturity is adapted. The consistently higher yields and improved seed quality of the new varieties in comparison with those of older varieties contributed greatly to profitable soybean production in the South.

"Hidden oxidation" found to be a major factor in quality of soybean oil. The most important problem of the soybean oil industry is decrease in flavor during storage or upon exposure to heat when used as a cooking oil. On exposure to air, soybean oil immediately begins to deteriorate by oxidation of the linolenic acid component. Most of the volatile flavor components of these oxidative decomposition products are removed during the deodorizing stage of the refining. However, utilization research found that about 90 percent of the total decomposition products remain in the refined oil. Taste panel studies have shown that with time these residual products undergo further changes which reduce the flavor and oxidative stability of oil that may appear to be of high quality immediately after refining. The effects of these unremoved oxidation products have been called "hidden oxidation". Methods for detecting hidden oxidation have been developed by the Department, and industry is now using them.

Linseed oil emulsion paints in commercial production. Over 50 paint manufacturers are making linseed oil emulsion paints using formulations that the Department's utilization research assisted in developing. Two linseed oil companies are producing oil emulsion bases and a third company is expected to enter the market shortly. Paint companies combine the emulsion base with pigment dispersions and other necessary ingredients to make the finished paint. If the current consumer acceptance of linseed oil emulsion paints continues, the decline in paint use of linseed oil should be halted and lost markets regained.

Mechanization of Peanut Grading. A new system and equipment for sampling and grading farmers stock peanuts, whereby the sample is automatically selected in a manner which provides a much more representative sample than was heretofore possible, then shells, counts, and determines the grade more accurately and in a fraction of the time formerly required.

Basis Provided For Revision of Peanut Price Support Differentials: -- Results of an intensive study of economic factors underlying price support differentials for the four principal types of farmers' stock peanuts provided the basis for revision of the differentials recommended by a special industry advisory committee, and adopted by the Department, for the 1962 crop. The study, based mainly on trends in peanut shellers' operating margins, geographic movements, and end-product uses, indicated the direction and magnitude of desirable changes in the price differentials under the peanut price support program.

I. FARM RESEARCH

SOYBEAN CULTURE, BREEDING AND GENETICS, DISEASES, AND VARIETY EVALUATION
Crops Research Div., ARS

Problem. The flowering and maturity of soybean varieties are determined primarily by photoperiod, and the maturity requirement alone necessitates a large number of varieties. The diseases of soybeans differ in various areas of the country and disease problems have increased greatly in recent years. Similarly, the responses of soybean varieties to soil nutrients differ greatly from one region to another and even from one portion of a State to another. The two components of the soybean seed for which soybeans are produced commercially, oil and protein, are negatively correlated and maximum breeding progress in the two components requires a separate breeding program for each. More precise research information is needed on the probable gains to be made in programs in which only oil or protein is considered individually, in which they are considered simultaneously, and in which only yield and other agronomic characteristics are considered without reference to chemical composition; on why soybeans generally fail to respond to commercial fertilization and why the maximum attainable yields of soybeans are relatively low in comparison to other crops; on the interrelationships of strains of nodulating bacteria and soybean varieties; and on the disease organisms affecting soybeans, in particular newly discovered seed-borne bacteria and some of the more devastating diseases such as Phytophthora rot and the soybean cyst nematode. There is also a need for the introduction, development, or identification of sources of resistance to some of the important diseases such as stem canker and brown stem rot.

USDA PROGRAM

The Department has a continuing long-term program involving geneticists, plant pathologists, physiologists, and biochemists engaged in both basic studies and the application of known principles to the solution of growers' problems. Genetics and breeding research is conducted at the Southwestern Irrigation Field Station at Brawley, California; Beltsville, Maryland; and in cooperation with the agricultural experiment stations at Gainesville, Florida; Urbana, Illinois; Lafayette, Indiana; Ames, Iowa; Stoneville, Mississippi; Columbia, Missouri; and Raleigh, North Carolina. In addition, the evaluation of experimental selections from the genetics and breeding research is conducted in formal cooperation with the experiment stations at Auburn, Alabama; Fayetteville, Arkansas; Experiment, Georgia; Manhattan, Kansas; Lexington, Kentucky; Baton Rouge, Louisiana; E. Lansing, Michigan; St. Paul, Minnesota; Lincoln, Nebraska; Fargo, North Dakota; Columbus, Ohio; Stillwater, Oklahoma;

Clemson, South Carolina; College Station, South Dakota; Knoxville, Tennessee; College Station, Texas; Blacksburg, Virginia; and Madison, Wisconsin; and in informal cooperation with experiment stations in other soybean producing States. Research on soybean diseases is conducted in cooperation with the agricultural experiment stations at Stoneville, Mississippi; Raleigh, North Carolina; Urbana, Illinois; Lafayette, Indiana; and Ames, Iowa. The variety evaluation research is conducted with the same type of cooperation as that for genetics and breeding. Research on culture and physiology is conducted in cooperation with the experiment stations at Urbana, Illinois; Lafayette, Indiana; Ames, Iowa; Stoneville, Mississippi; Columbia, Missouri; and at Beltsville, Maryland and Brawley, California.

The Federal scientific effort devoted to research in this area totals 17.8 professional man-years. Of this number 7.9 is devoted to breeding and genetics; 5.0 to diseases; 1.7 to variety evaluation; 2.5 to culture and physiology; and 0.7 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 20.2 professional man-years divided among subheadings as follows: genetics and breeding 9.4, diseases 2.7, variety evaluation 1.8, and culture and physiology 6.3. Illinois is engaged in cytological studies with soybeans and is searching for chromosomal and genetic characteristics that may expedite breeding. Minnesota and Ohio have breeding programs involving breeding for disease resistance and other important characteristics in soybeans. Effects of radiation on quantitative characters in soybeans are being studied at Nebraska. Research on all aspects of soybean diseases, especially those affecting seed quality, is conducted in Delaware.

Industry and other organizations, primarily seed companies, are attempting to improve soybean varieties by selecting within existing strains, and one seed company has an extensive and well planned breeding program. This company cooperates with the Department by furnishing seed of advanced breeding lines for testing and by evaluating the performance of strains developed in cooperative work of the Department. Estimated annual expenditures are equivalent to approximately 1 professional man-year.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics and Breeding

Two new soybean varieties released in 1961 were popular with the relatively few growers who were able to get seed of them for 1961 plantings. Kent in particular was high yielding throughout its adapted area and appeared to have a high degree of resistance to pod and stem blight in Delaware and Maryland. This resulted in great

increases in seed quality from this variety in these areas, but the high incidence of purple seed in Kent is an undesirable characteristic of the variety. Bethel performed well in Delaware and Maryland and produced seed unusually high in quality for the area. Although slightly inferior to Kent in most agronomic characteristics, it may prove to be a better variety for Delaware and Maryland because of seed quality.

Several varieties to which resistance to Phytophthora rot had been transferred by backcrossing were evaluated extensively in 1961. Two of these, Harosoy and Hawkeye, will be released in January 1963; and Clark, which has been converted to pustule resistance in addition to Phytophthora, also will be released in 1963. The three resistant varieties have yielded essentially as much as their susceptible counterparts in the absence of Phytophthora and much more than their susceptible counterparts when the disease is present. The three varieties will mark the first soybean varieties developed by the backcross method and released to growers.

The transfer of resistance to the cyst nematode to the Lee variety was continued through the fourth backcross in 1961. Based on greenhouse evaluations and limited field testing, the resistance of the resistant variety Peking seems to have been maintained through the fourth backcross generation. However, an unusual and unexpected linkage between resistance and seed coat color was encountered in the attempt to isolate yellow-seeded resistant plants for seed increase and possible release to growers. Yellow-seeded resistant plants were identified with ease, but in all cases the progenies from these plants segregated for seed coat color and resistance to the nematode. Yellow-seeded resistant plants have segregated in this manner through three generations of selection thus far evaluated. Apparently the gene conditioning the distribution of dark pigment in the seed coat is genetically linked with one of the genes for resistance or the gene conditioning the distribution of pigments acts in this capacity as well as in conditioning resistance to the nematode. If the condition is due to genetic linkage, it should be possible, with time and extensive evaluations, to isolate a true breeding, yellow-seeded line resistant to the cyst nematode. If, however, the condition is due to a dual effect of a single gene, it may be impossible to develop improved yellow-seeded varieties having the high degree of resistance of the black-seeded Peking parent.

In Iowa, a study of the effects of colchicine treatment, to ascertain whether results similar to those reported for sorghum could be obtained, was completed. The results were negative with the only apparent type of mutation involved being the production of numerous autotetraploid plants. No simple mutations or measurable deviations from normal were obtained.

In Indiana, soybean plants infected with the tobacco ringspot virus were found to outcross with neighboring healthy plants on an average of 9 percent with maximum outcrossing being as high as 40 percent on individual plants. This level of outcrossing would be of practical utility in intermating soybean populations and may prove to be valuable in this regard. The virus is seed transmitted at a rate of 80 to 90 percent; and once the virus is established in the population to be intermated, the 10 to 20 percent of the plants in which the virus is not seed transmitted could serve as pollen parents and permit the isolation of virus-free plants when the intermating is completed.

Competition between plants within the same row in a segregating population and between rows in strain evaluation has long been a complicating factor in soybean breeding. Work completed in 1961 clearly demonstrated that there is no spacing between plants at which all plants in a segregating population have equal opportunity for expression of the genotype. If spacing is too close, some plants will have a competitive advantage over others and will yield more because of this competitive advantage while those at a competitive disadvantage will yield less. As spacing is increased, some plants reach the maximum space they can utilize quicker than others, and those with a capacity to utilize maximum space will yield much more than the others. Thus, as far as yield of individual soybean plants in segregating populations is concerned, individual plant performance is virtually useless as a criterion of selection in the breeding program. Similarly, competition between rows of experimental strains may adversely affect the results. Differential competition between strains is at a significant level for maturity groups IV through VIII but is much less significant in the earlier maturing types. Competition between rows appears to be general rather than specific and soybean lines can be ranked for their competitiveness. This makes it possible to separate individual or double rows of experimental strains with a common competing type and thus minimize the effects of competition and greatly facilitate evaluation over what would be involved with bordered plots.

At Beltsville, Maryland, the effectiveness of visual selection for yield versus selection based on measured yields was investigated. The results indicated that three experienced soybean breeders effectively discarded the lowest yielding 50 percent of the lines in segregating populations. However, the accuracy with which the top yielding lines were ranked was low. The results indicate that the poorest 50 percent of the lines in segregating populations of soybeans can be discarded by the simple procedure of visual observation, thus permitting the handling of large numbers of selections in early segregating generations. The precision of such selection is directly proportional to the range in yield of the selections under consideration.

In Illinois, the tolerance vs. intolerance of soybean varieties to high levels of phosphorus was found to be fairly simply inherited although the exact nature of the inheritance is still in question. The mode of inheritance is, however, simple enough to permit the development of near isogenic lines, one of which is tolerant to phosphorus and one intolerant. Such lines are currently being developed and should prove to be of great value in research on phosphorus nutrition of plants.

B. Diseases

At North Carolina, the interaction of a soil-borne Fusarium fungus and the soybean cyst nematode was confirmed. In treatments involving various combinations of cyst nematode, root-knot nematode, and the Fusarium fungus, severe vascular discoloration and stunting of the plants resulted only when the fungus and the cyst nematode were in combination. The fungus was consistently reisolated from the affected plants.

In the cooperative program involving the evaluation of the entire germplasm collection for resistance to tobacco ringspot virus, only 4 of the 37 selections that appeared to be resistant in 1960 proved to be resistant in 1961.

In Iowa, an unidentified species of Corynebacterium not previously reported pathogenic on soybeans caused severe stunting of seedlings. The bacteria were seed-transmitted in vascular elements of dormant seed and growth was greatly retarded in infected seedlings. Evaluation of seed collected from many areas of the United States indicated that the causal organism is widespread and the disease appears to be associated with a number of other leaf and stem diseases.

In Iowa, a common disease of soybeans, bacterial blight, was found to be caused by two species of bacteria rather than one. The symptoms produced by the two organisms are essentially identical, but the characteristics of the two species in culture are distinctly different.

C. Variety Evaluation

The evaluation of soybean varieties for chemical composition is an integral part of research in genetics and breeding, and the results of such evaluations are utilized in interpreting the total information from genetics and breeding studies.

In analyzing soybeans for chemical composition, the seed involved in the analyses are destroyed and are no longer available for planting. In many instances a technique that would provide an indication

of the oil or protein content of the seed and still leave them available for planting would facilitate the genetics and breeding research program. In cooperative research in Illinois and Mississippi, the specific gravity of the seed was found to be correlated in a positive direction with protein and in a negative direction with oil. Various combinations of glycerol and water were used to separate soybean seed into various density classes and the density class was found to be associated with the oil and protein contents. The technique appears to have possibilities in identifying seed with either a high oil or high protein content and still leave seed available for planting for future evaluations. The technique is currently being investigated for its utility in selecting seed of the desired composition from hybrid populations.

D. Culture and Physiology

Differential competition between strains of soybean nodulating bacteria has been demonstrated to occur in the greenhouse and in field soils essentially free of nodulating bacteria. In 1961 extensive field tests were conducted to evaluate the competition of strains applied as inoculum on the seed with the strains already present in field soils that had recently produced a crop of well nodulated soybeans. The tests were conducted on five different soils in Maryland, Mississippi, South Carolina, and Iowa. In all instances the serological types present in the soils were identified in advance of planting and strains selected for use in the inoculum that could be identified from those already present in the soils. In four of the tests the usual commercial procedure of inoculation was followed, whereas in the Iowa test an unusually large quantity of inoculum was applied about 2 weeks after planting but before the plants had emerged. This latter treatment was prompted by the fact that unusually dry weather delayed emergence and the additional inoculation was made in the event that the weather had also resulted in the death of the bacteria applied as inoculum on the seed. The results of the four tests using the usual commercial procedure of inoculation were consistent and indicated that less than 1 percent of the nodules on the plants were caused by the strains applied as inoculum on the seed. In contrast, as high as 40 percent of the nodules were caused by the strains applied in the heavy inoculation treatment in the Iowa test. The results appear to indicate that inoculation of soybean seed by the usual recommended procedure is ineffective if the seed are to be planted in soils already contaminated with nodulating bacteria. Since most of the soils in the soybean producing areas of the United States are contaminated, the results suggest a re-evaluation of inoculation procedures and recommendations for soybeans.

In California, a test of 21 strains of nodulating bacteria in uncontaminated soil on the variety Lee indicated marked differences in the strains in effectiveness of nitrogen production. Some strains

resulted in the retention of green leaves and stems after plants receiving other strains were mature, a symptom similar to that sometimes observed from high levels of fertilizer nitrogen. Yields from treatments involving the 21 strains ranged from 32 to 45 bushels per acre, indicating that yields of soybeans can be increased from nodulation by selected strains of nodulating bacteria. Similar results were obtained in the Iowa test in contaminated soil; but, as expected, the differences due to strains were smaller since a maximum of 40 percent of the nodules were produced by the strains being tested.

In California, resistance of salt damage in the germinating stage and the growth stage of soybeans appeared to be largely independent. Some varieties tolerant to salt in germination proved to be susceptible to salt in growth of the plants, and other varieties highly tolerant of salt in the growth of the plants were susceptible to salt in germination. Variations in salt tolerance, as indicated by growth and seed production, were striking, with some varieties producing essentially normal yields at levels of salt in the soil that resulted in death of other types.

In Illinois, phosphorus toxicity of sensitive varieties was found to be associated with the level of calcium and potassium in the nutrient solution. When these two nutrients were increased to the same proportionately high level as phosphorus, no toxicity symptoms developed. When either, alone, or other individual components of the nutrient solution were increased to the proportionately high level of phosphorus, the phosphorus toxicity symptoms were not affected. This work indicated that the differences in phosphorus response of soybean varieties are not closely related to iron inefficiency since the iron inefficient line used extensively in experiments with iron nutrition proved to be tolerant to high phosphorus levels. Research on the uptake of phosphorus by tolerant and intolerant varieties indicated that tolerance may involve a monitoring or regulatory mechanism which acts to prevent accumulation of excessive amounts of phosphorus since the uptake of phosphorus by intolerant varieties was much higher at high levels of phosphorus than the uptake by tolerant varieties.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Genetics and Breeding

Brim, C. A., and Cockerham, C. C. 1961. Inheritance of quantitative characters in soybeans. Crop Sci., 1(3), pp. 187-190.

Caldwell, B. E., Brim, C. A., and Ross, J. P. 1960. Inheritance of resistance of soybeans to the cyst nematode, Heterodera glycines. Agron. J., 52(11), pp. 635-636.

Casas, E. 1961. Induction of male sterility in soybeans. M.S. Thesis, North Carolina State College, Raleigh, North Carolina.

Chamberlain, D. W., and Bernard, R. L. 1961. The search for resistance to brown stem rot of soybeans. Illinois Research, 3(3), pp. 18-19.

Dunleavy, J. M., Weber, C. R., and Chamberlain, D. W. 1960. A source of bacterial blight resistance for soybeans. Proc. Iowa Acad. Sci., 67, pp. 120-125.

Hanson, W. D. 1961. Effect of calcium and phosphorus nutrition on genetic recombination in the soybean. Crop Sci., 1(5), p. 384.

Hanson, W. D., and Weber, C. R. 1961. Resolution of genetic variability in self-pollinated species with an application to the soybean. Genetics, 46(11), pp. 1425-1434.

Hanson, W. D., and Weber, C. R. 1962. Analysis of genetic variability from generations of plant-progeny lines in soybeans. Crop Sci., 2(1), pp. 63-67.

Hanson, W. D., Brim, C. A., and Hinson, K. 1961. Design and analysis of competition studies with an application to field plot competition in the soybean. Crop Sci., 1(4), pp. 255-258.

Hanson, W. D., Leffel, R. C., and Howell, R. W. 1961. Genetic analysis of energy production in the soybean. Crop Sci., 1(2), pp. 121-126.

Hanson, W. D., Leffel, R. C., and Johnson, H. W. 1962. Visual discrimination for yield among soybean phenotypes. Crop Sci., 2(2), pp. 93-96.

Hartwig, E. E. 1962. Lee continues to lead soybean varieties in Mississippi. Mississippi Farm Research, 25(3), p. 3.

Hartwig, E. E., and Collins, F. I. 1962. Evaluation of density classification as a selection technique in breeding soybeans for protein or oil. Crop Sci., 2(2), pp. 159-162.

Hartwig, E. E., and Hinson, K. 1962. Inheritance of flower color of soybeans. Crop Sci., 2(2), pp. 152-153.

Hinson, K. 1959. Soybean breeding in Florida. Proc. Florida Soil and Crop Sci. Soc., 19, pp. 105-114.

Hinson, K., and Hanson, W. D. 1962. Competition studies in soybeans. Crop Sci., 2(2), pp. 117-123.

Howell, R. W., and Bernard, R. L. 1961. Phosphorus response of soybean varieties. Crop Sci., 1(5), pp. 311-313.

Johnson, H. W. 1960. Registration of soybean varieties, VII. Agron. J., 52(11), pp. 659-660.

Johnson, H. W. 1961. Breeding for oil and protein in soybeans. Soybean Dig., 21(11), pp. 73-75.

Johnson, H. W., and Means, U. M. 1960. Interactions between genotypes of soybeans and genotypes of nodulating bacteria. Agron. J., 52(11), pp. 651-654.

Leffel, R. C. 1961. Plant lodging as a selection criterion in soybean breeding. Crop Sci., 1(5), pp. 346-349.

Leffel, R. C., and Hanson, W. D. 1961. Early generation testing of diallel crosses of soybeans. Crop Sci., 1(3), pp. 169-174.

Probst, A. H., and Athow, K. L. 1961. Kent soybean. Purdue Agr. Expt. Sta. Mimeo. ID-52.

Voigt, R. L., and Weber, C. R. 1960. Effectiveness of selection methods for yield in soybean crosses. Agron. J., 52(9), pp. 527-530.

Weber, C. R. 1961. Iowa soybean variety trial summary - 1956-60. Iowa State Univ. Agron. 510.

Weber, C. R. 1962. Iowa soybean variety trial summary - 1957-61. Iowa State Univ. Agron. 551.

Weber, C. R., and Hanson, W. D. 1961. Natural hybridization with and without ionizing radiation in soybeans. Crop Sci., 1(6), pp. 389-392.

White, H. B., Jr., Quackenbush, F. W., and Probst, A. H. 1961. Occurrence and inheritance of linolenic and linoleic acids in soybean seeds. J. Am. Oil Chemists' Soc. 38(3), pp. 113-117.

1961. Results of the cooperative uniform soybean tests, 1960. Part I. North Central States, RSLM 206. Part II. Southern States, RSLM 207.

1962. Results of the cooperative uniform soybean tests, 1961. Part I. North Central States, RSLM 211. Part II. Southern States, RSLM 212.

Diseases

Athow, K. L., and Laviolette, F. A. 1961. The relation of seed-transmitted tobacco ringspot virus to soybean yield. Phytopath., 51(5), pp. 341-342.

Athow, K. L., and Probst, A. H. 1961. Indiana soybean disease and crop condition survey, 1961. Purdue Univ. Agr. Expt. Sta. Mimeo. ID-39.

Calvert, O. H., Williams, L. F., and Whitehead, M. D. 1960. Frozen-lima-bean agar for culture and storage of Phytophthora sojae. Phytopath., 50(2), pp. 136-137.

Chamberlain, D. W. 1961. Reduction in water flow in soybean stems caused by a metabolite of Cephalosporium gregatum. Phytopath., 51(12), pp. 863-865.

Dunleavy, J. 1961. Recent progress in soybean disease research. Soybean Dig., 21(9), pp. 10-12.

Dunleavy, J. 1961. Fusarium blight of soybeans. Proc. Iowa Acad. Sci., 68, pp. 103-108.

Dysart, R. J., and Chamberlain, D. W. 1960. Studies on transmission of tobacco ringspot virus on soybean and weed suscepts. Plant Dis. Reptr., 44(12), pp. 952-954.

Ferris, V. R., and Bernard, R. L. 1961. Seasonal variations of nematode populations in soybean field soil. Plant Dis. Reptr., 45(10), pp. 789-793.

Ferris, V. R., and Bernard, R. L. 1962. Injury to soybeans caused by Pratylenchus alleni. Plant Dis. Reptr., 46(3), pp. 181-184.

Johnson, H. W., and Jones, J. P. 1961. Other legumes prove susceptible to a powdery mildew of Psoralea tenax. Plant Dis. Reptr., 45(7), pp. 542-543.

Johnson, H. W., and Jones, J. P. 1962. Purple stain of guar. Phytopath., 52(3), pp. 269-272.
Jones, J. P. 1961. A weed host of Xanthomonas phaseoli var. sojense. Phytopath., 51(3), p. 206.
Jones, J. P. 1961. A leaf spot of cotton caused by Corynespora cassiicola. Phytopath., 51(5), pp. 305-308.
Pederson, V. D. 1960. Self-inhibition of germination of the conidia of Peronospora manshurica. Proc. Iowa Acad. Sci., 67, pp. 103-108.
Ross, J. P. 1960. Heterodera trifolii - a foliage pathogen of white clover. Phytopath., 50(11), pp. 866-867.
Wells, J. C., and Ross, J. P. 1961. Some important diseases of soybeans in North Carolina. N. C. State College Plant Pathology Information Note No. 74.
Wyllie, T. D. 1962. Effect of metabolic by-products of Rhizoctonia solani on the roots of Chippewa soybean seedlings. Phytopath., 52(3), pp. 202-206.

Variety Evaluations

Krober, O. A., and Gibbons, S. J. 1962. Nonprotein nitrogen in soybeans. Agr. and Food Chem., 10(1), pp. 57-59.

Culture and Physiology

Abel, G. H., Jr. 1961. Response of soybeans to dates of planting in the Imperial Valley of California. Agron. J., 53(2), pp. 95-98.
Beeson, K. E., and Probst, A. H. 1961. Soybeans in Indiana. Purdue Univ. Ext. Bull. 231. (Rev. 1961).
Bils, R. F. 1960. Biochemical and cytological changes in the developing soybean cotyledon. Ph.D. thesis, University of Illinois, Urbana, Illinois.
Cherry, J. H., Hageman, R. H., Collins, F. I., and Flesher, D. 1961. Effects of X-irradiation on corn seed. J. Plant Physiol., 36(5), pp. 566-572.
Galitz, D. S. 1960. Studies on the occurrence and physiological properties of a natural inhibitor of germination of immature soybean seeds. M.S. Thesis, University of Illinois, Urbana, Illinois.
Hartwig, E. E. 1961. Soybeans--variety, row width studies. Mississippi Farm Research, 24(3), p. 3.
Howell, R. W. 1961. Physiological comparisons of soybeans and corn. Soybean Dig., 22(1), pp. 16-18.
Howell, R. W. 1961. Changes in metabolic characteristics of mitochondria from soybean cotyledons during germination. Physiologia Plantarum, 14, pp. 89-97.
Johnson, H. W., Borthwick, H. A., and Leffel, R. C. 1960. Effects of photoperiod and time of planting on rates of development of the soybean in various stages of the life cycle. Botan. Gaz., 122(2), pp. 77-95.

Johnson, H. W., Cartter, J. L., and Hartwig, E. E. 1960. Soybean varieties and nutrition. Soybean Dig., 20(7), p. 17.

Kahn, V., Howell, R. W., and Hanson, J. B. 1960. Fat metabolism in germinating soybeans. I. Physiology of native fat. Plant Physiol., 35(6), pp. 854-860.

Krober, O. A., and Cartter, J. L. 1962. Quantitative interrelations of protein and nonprotein constituents of soybeans. Crop Sci., 2(2), pp. 171-172.

Kuehl, R. O., 1961. Pollen viability and stigma receptivity of Glycine max (L.) Merrill. M.S. Thesis, North Carolina State College, Raleigh, North Carolina.

Leffel, R. C., and Barber, G. W., Jr. 1961. Row widths and seeding rates in soybeans. Univ. of Maryland Agr. Expt. Sta. Bull. 470.

Means, U. M., Johnson, H. W., and Erdman, L. W. 1961. Competition between bacterial strains effecting nodulation in soybeans. Proc. Soil Sci. Soc. Am., 25(2), pp. 105-108.

Miksche, J. P. 1961. Developmental vegetative morphology of Glycine max. Agron. J., 53(2), pp. 121-128.

Weaver, H. L. 1960. Vascularization of the root-hypocotyl-cotyledon axis of Glycine max (L.) Merrill. Phytomorphology, 10(1), pp. 82-86.

OILSEED CULTURE,
BREEDING, DISEASES, AND VARIETY EVALUATION
Crops Research Div., ARS

Problem. Rapid expansion in safflower acreage to meet the increased demand for edible oils high in polyunsaturated fatty acids has increased the number and magnitude of the problems in growing this relatively new crop. Root rot and rust have increased in importance on irrigated and subirrigated land. Verticillium wilt is found more frequently in commercial fields and breeding nurseries, and in some years the virus diseases have been a serious threat to the crop. Reduction in hull percentage is of great importance in producing meal high in protein without the excess fiber now found in meal from undecorticated seed. Studies of cultural practices are required to insure economical production.

For peanuts, more precise information is needed on: (1) Nature of important diseases and their control; (2) the physiology of the plant including the nature of its unique reproductive system, mineral nutrition, and environmental factors affecting growth, and flowering and fruiting; (3) breeding behavior of the crop, including identification of and method of inheritance of characters of economic importance; and (4) identifying and measuring objectively those characteristics of peanuts that are associated with quality for specific end uses. Improved varieties with higher yield potential, resistance to diseases and insects, increased market acceptability, and enhanced nutritional properties are urgently needed to reduce the cost per unit of production of higher quality peanuts, thereby encouraging increased consumption of peanuts and peanut products and possible use of peanuts for industrial purposes.

The major problem of flax production is breeding varieties with higher yield of seed, higher oil content and iodine number, and greater resistance to disease. More basic knowledge is needed of the physiology and nutrition of the flax plant to increase yield. Further basic studies are needed on the chemistry of oil quality. The flax plant also serves in basic studies of the nature of the hypersensitive type of resistance to plant diseases.

Castorbean production is profitable in areas of adaptation. Increases in yield through breeding dwarf-internode lines that combine well in F_1 hybrids, have resistance to disease, lodging and shattering, and are suited to mechanical harvest would permit considerable expansion in acreage. Resistance to Alternaria leaf spot and capsule mold is needed urgently in Texas and lack of resistance to diseases causing capsule drop prevents profitable production in the humid

areas east of Texas.

The most urgent problem in profitable sesame production is the development of high-yielding, non-shattering varieties, easy to thresh, resistant to diseases, and with seed quality suited to the trade.

Attempts at commercial production of sunflower have not been entirely successful, largely because of damage by the head moth and by rust. Introduced varieties and breeding lines are reported to have resistance to these pests, and the major problem is to screen available materials and see if there is a source of resistance sufficiently high to encourage a breeding program to develop resistant varieties with high yield and high oil content. Sunflower could serve well as a source of edible oil high in polyunsaturated fatty acid in areas where crops producing similar oils are not well adapted.

Tung is a very promising crop for a band just north of the Gulf of Mexico extending from south Georgia to east Texas except it has a low dormancy chilling requirement, hence begins to grow with the first warm weather and the flower buds get caught by late spring frosts. Methods are needed, either chemically to keep trees dormant, nutritionally or culturally to make trees more cold hardy or through breeding to find or develop a more cold hardy or later blooming clone. Disease, mycosphorella, leaf spot, in some years, defoliates trees early, reducing oil content; control for this disease, either chemical or through breeding, is urgently needed. More information on spacing, nutrition, cultural practices, and variety testing is needed to enable more consistent and higher production at less cost.

USDA PROGRAM

The Department has a continuing long-term program involving geneticists, plant pathologists, biochemists, physiologists, horticulturists, and agronomists engaged in both basic and applied studies of known principles to the solution of growers' problems. Safflower breeding, disease and cultural research is being carried on in cooperation with the California, Utah, Arizona, and Nebraska Agricultural Experiment Stations. Peanut breeding and variety evaluation research at Tifton, Georgia, and peanut disease investigations at Experiment, Plains, and Tifton, Georgia are cooperative with the Georgia Experiment Stations. Disease, culture, and variety evaluation research at Auburn and Headland, Alabama is cooperative with the Alabama Experiment Station. Peanut disease and variety evaluation research at Holland, Virginia is cooperative with the Virginia Experiment Station. Peanut variety evaluation and seed physiology research is carried on at Beltsville, Maryland. Flax research is conducted cooperatively with the Minnesota, North Dakota, and South Dakota Agricultural Experiment Stations, and at the Southwest Irrigation Field Station, Brawley, California. Castorbean breeding and

genetics, disease control, and cultural trials are conducted in cooperation with the California, Texas, Oklahoma, and Mississippi Agricultural Experiment Stations. Sesame and Sunflower research is conducted in cooperation with the Texas Agricultural Experiment Station. The Department has a continuing long term tung program carried on at one central field location to Bogalusa, La., with a field laboratory at Cairo, Ga. The work is cooperative with the experiment stations of Mississippi and Louisiana. Much of the field work and experimental plantings are at the Mississippi Experimental Tung Farm, Poplarville, Mississippi.

The Federal scientific effort devoted to research in this area totals 31.8 professional man-years. Of this number, 9.2 is devoted to genetics and breeding; 8.2 to diseases; 4.2 to variety evaluation; 10.4 to culture; and 1.1 to program leadership. Pathologic research (safflower, castorbean, sesame, and mint) is carried on at Beltsville, Maryland. There is also 4.1 professional man-years engaged in research on oilseeds and peanut introduction and evaluation.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 16.6 professional man-years divided among subheadings as follows: Breeding and genetics 5.3, diseases 3.2, variety evaluation 2.7, and culture 5.4. California, Nebraska, and Arizona are conducting basic genetic and breeding work on safflower. Peanut breeding programs are in progress in Florida and North Carolina with modest programs in Oklahoma, Texas, and Virginia. Intensive studies are being made in North Carolina on the use of radiation in peanut breeding. Peanut disease investigations are carried on in Alabama, Georgia, North Carolina, and Virginia with varying emphasis on stem rot, collar rot, leafspots, pod rot, root rot, concealed damage of seed, and nematode disorders. All seven major peanut producing states have peanut variety evaluation programs to study adaptation of varieties in different parts of respective states. Peanut mineral nutrition, fertilization, and crop rotation studies, as well as investigations of harvesting and curing procedures from mechanical standpoint and as related to processing quality, are carried on with varying emphasis in Alabama, Florida, Georgia, Oklahoma, North Carolina, Texas, and Virginia. North Dakota, South Dakota, Texas, and California are working on breeding and basic genetics of flax. Nebraska has a state program on breeding, variety evaluation, and culture of castorbeans. Mississippi devotes approximately 1 professional man-year in culture and Louisiana less than .5 man-year, in tung research.

Industry is engaged in breeding research to improve varieties of safflower and castorbeans. Many of their research findings are kept confidential. They cooperate with Federal and State workers by testing new varieties of safflower and castorbean and by making and testing F_1 castorbean hybrids using one or both parents developed by the U. S. Department of Agriculture. The companies cooperate by evaluating new methods of disease control developed by Federal

workers. Estimated annual expenditures are equivalent to approximately 3 professional man-years. The American Tung Oil Association devotes some time to research, particularly to improve tung oil as a product and to find new uses.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Safflower. U-1421, a safflower line resistant to at least 4 races of safflower rust, and to both high and lower temperature strains of Phytophthora, has been released to safflower breeders. It has good oil content and fair yield, and should be valuable in a breeding program. Some of the selections made from U-1421 have produced good yields in limited trials, but have been only average in oil content.

Preliminary tests of the progeny of a single plant selected from P.I. 253,914 indicate a different type of rust resistance than that found in U-1421. An attempt is being made to evaluate this line for use in breeding rust-resistant varieties. Early tests of several new lines have shown much promise in higher yield of both seed and oil. A striped-hull selection from Gila produced seed with 45.1 percent oil. Single plant selections from crosses of striped-hull x normal or striped-hull x thin-hull appear better than the original striped-hull line, and ranged from 43.6 to 49.4 percent oil.

2. Peanut. At Tifton, Georgia, where improvement in yield, resistance to insects and diseases, and in shelling, processing and nutritional properties are being sought for all major market types of peanuts, 2,000 individual plant selections were made in 1961 from progenies of crosses made during the past 8 years. Concurrently, genetic studies involving inheritance and breeding methodology investigations are in progress to take some of the guesswork out of breeding and thereby increase efficiency of future breeding programs.

Genetic markers are expediting inheritance and other genetic and cytogenetic studies at Tifton. Krinkle-leaf, a spontaneous mutant of Spanish origin, has been found to be partially dominant, but the degree of intermediacy is so slight that both the homozygous dominant and the heterozygous genotypes can be treated as a single phenotypic marker in genetic studies. Krinkle-leaf, which is easily detectable in early growth of the seedling, is being used as a genetic marker in studies of seedcoat color inheritance, the nature of the inheritance of other foliage mutants with potential value as genetic markers, the prevalence of linkage in inheritance of characters in the peanut, and the prevalence of natural crossing in peanuts.

The peanut has been considered to be self pollinated with little or no natural crossing. Studies at Tifton, involving more than 110,000

seedlings, have shown from 0 to 10 percent natural crossing when seed-bearing plants have been favorably exposed to Krinkle-leaf Spanish pollen. A 15-foot barrier of either corn, southern peas, or lima beans failed to reduce natural crossing effectively. Circumstantial evidence indicates that bees are probably the carriers of pollen involved in natural crossing. These findings have important implications from the standpoint of breeding methodology, production, and maintenance of clean peanut seedstocks, genetic diversity in cultivated peanuts, and speciation in the genus Arachis. Genetic studies designed to elucidate and possibly eventually solve these problems are in progress.

The existence of an appreciable level of natural crossing in peanuts has suggested the possible usefulness of "directed" natural crossing as a new breeding technique for peanuts, particularly useful in a practical breeding program and for the development of genetic stocks for inheritance studies when used in conjunction with appropriate genetic markers. Directed natural crossing has been used at Tifton to establish stocks for inheritance studies in cultivated peanuts and to make natural hybrids with a wild annual peanut.

Crosses have been made between several wild species of annuals and 9 varieties of cultivated peanuts. Characteristics of certain wild species of Arachis that might be incorporated advantageously into cultivated peanuts are unusual plant vigor, profuse branching, adventitious roots on pegs, and apparent resistance to Cercospora leafspot.

3. Flax. Two new varieties of flax were named and released in cooperation with the Minnesota Experiment Station. Windom, a selection of /(Renew x Bison)(Koto x Redwing)/Redwood/ has high seed yield potential whether sown early or late. It is slightly below average in oil content but has excellent oil quality. Marine 62 is a selection from Marine that is superior to Marine in oil content, slightly higher in seed yield, and otherwise similar in disease reaction and agronomic traits.

The new winter-type variety, Caldwell, produced outstanding yields when grown commercially on 200 acres in Texas. The winter hardiness of the variety was demonstrated when it survived 17° temperature for 3 consecutive days in January of 1962. Nearly all other varieties succumbed to the cold temperature.

Initial evaluations were made of 400 plant lines of Bison that possess either the LM^3N' or LM^3P^3 rust immunity genes. Lines that are superior in agronomic and seed quality traits will be increased and tested as possible new varieties. Multiple genes for rust immunity insure protection against the occurrence of new rust races by mutation that may attack present varieties possessing but one gene for rust immunity.

Extensive tests have shown that genes conditioning rust reaction in the M and L series, heretofore considered allelic series, are not alleles but are closely linked with less than one percent crossing over. Thus, it is possible to incorporate more genes for rust resistance within a variety than formerly was thought possible. There was no evidence of crossing over between genes at either the L or P locus.

Comparisons of yellow-seeded lines (gg) with homologous brown-seeded lines(GG) showed no differences in seed yield. However, the yellow-seeded lines were higher in oil percent and oil quality, early flowering, shorter, and had smaller seed of lower germination. Another yellow-seeded character conditioned by the b'b' gene caused seed to lose viability more rapidly under three storage conditions than seed from homologous brown-seeded lines (B'B').

Progress is being made to combine high seed yield potential with wilt resistance in winter-type varieties for irrigated areas in the Southwest. Sixteen wilt-resistant selections were found by preliminary yield tests to be equal to or higher yielding than the commercial variety Imperial. Evaluations of these and other promising selections will be continued.

4. Castorbean. Two dwarf-internode pistillate lines were released to plant breeders in 1961 for testing as female parents in F_1 hybrid combinations. TSP-10, an S-pistillate line developed in Texas, is highly resistant to Alternaria leaf spot and bacterial leaf spot. CNP-1, an N-pistillate line developed in California, has shown good combining ability in the Sacramento Valley for yield and oil content.

Performance tests of dwarf-internode F_1 hybrids were conducted for the fourth year. In California 245 experimental dwarf-internode F_1 hybrids were tested in replicated yield trials. A wind storm before defoliation caused considerable plant lodging. The inbreds, Baker 296 and Baker 148, were outstanding in resistance to lodging. Hybrids with Baker 296 or Baker 148 as male parents had the most resistance to lodging. There was an association of susceptibility to lodging and high oil. Eleven dwarf-internode hybrids were tested with a commercial normal-internode F_1 hybrid check at four locations in the Sacramento Valley. The mean yield of the 11 dwarf-internode hybrids was 105 percent of the check with a range of 97 to 113; the mean oil content was 97 percent of the check with a range of 93 to 99. The variety-location interaction for yield was highly significant. At individual locations, the highest yielding dwarf-internode hybrid was 128 percent of the normal-internode hybrid, while the lowest was 85 percent. At Lubbock, Texas, in a 70-entry yield test of dwarf-internode hybrids and inbreds the highest yielding hybrid, C61DH-7, exceeded Hale, the highest yielding inbred, by 6 percent. At Plainview, Texas, the highest yielding hybrid exceeded Lynn, the highest yielding inbred, by 11 percent. Hale and F_1 hybrids made with Hale or Lynn were consistently high in yield in experimental

plantings on the High Plains in 1961. In a yield trial at Stoneville, Mississippi, three dwarf-internode F_1 hybrids produced an average yield of 2,750 pounds per acre, which is very high for non-irrigated production.

Sex studies continue to suggest that genotype-environment interactions for sex can be used in the development and propagation of female lines for use in the production of F_1 hybrid seed with little or no roguing of monoecious plants. Of 40 dwarf-internode N-pistillate sib-progenies at Brawley, California, 32 had ff pistillate plants which reverted to various degrees of interspersed-monoecism after about the third sequential raceme; while at Davis, California, none of the pistillate plants showed this tendency. Selfed seed was obtained on reverted plants at Brawley for progeny tests at several locations in 1962. Based on past experience, progenies from such reverted pistillate plants are expected to be pistillate when grown in Central California and the Texas High Plains, where the environment is conducive to the pistillate tendency. Reversion of ff N-pistillate Cimarron to interspersed monoecious has been observed for the fifth year at Stillwater, Oklahoma. Progenies of such reverted plants are pistillate at Davis.

At College Station, Texas, where selection pressure for pistillateness is being applied in S-pistillate material, sibbed seed from pistillate plants of TSP-10 and TSP-4 produced progenies on the Texas High Plains in which 98 and 100 percent of the plants, respectively, were pistillate in 1961. Over a 3-year period, 95 percent of the plants were pistillate in both varieties. TSP-10 and TSP-4 were overwintered at College Station with 52 and 56 percent of the plants surviving, respectively. Of the surviving plants, 88 percent of TSP-10 were pistillate on June 5, 1961; similarly 89 percent of TSP-4 were pistillate.

At Stoneville, Mississippi, 3-year data on the inheritance of resistance to capsule drop, a quantitative trait, suggests MW-1 possesses at least two gene pairs for resistance and Baker 296 one gene pair. The gene action seems to be additive; also, the two genes for resistance appear to be of equal value. The most promising material now in F_3 and F_4 generations appears to be from the crosses MW-1 x Baker 296 and MW-1 x selections of T53222. At Stillwater, Oklahoma, high humidity during the latter part of the growing season was conducive to strong selection pressure for resistance to capsule drop. Resistant selections were made from F_3 lines of MW-1 x Baker 296 and F_4 lines from (Cimarron Sel. 16 x RA 11-15-2-B-41) F_6 x Baker 296. The latter were not as resistant but were otherwise agronomically more desirable.

Crosses were made to continue the incorporation of Alternaria leaf spot resistance into Baker 296 and into N-pistillate lines at

College Station, Texas. At Stillwater, Oklahoma, a breeding and genetic study is underway in the cross of Baker 296 x Hale with special emphasis on resistance to Alternaria leaf spot and its relationship to time of flowering or number of nodes to the first raceme and between sequential racemes.

In a diallel cross experiment in California, eight normal-internode varieties, with a wide range in oil content, were mated in all possible combinations. The several estimators of kind of gene action showed dominance for high oil. No interallelic interaction was detected. The highly significant positive correlation ($r = 0.94$) of the parents and their F_1 offspring suggests that performance of the parents can be used as a selection criterion for oil content of their hybrids. The 28 F_1 hybrids ranged from 96 to 103 percent of their respective highest oil parents. Five hybrids were significantly higher ($P = 0.05$) than their highest parent.

In an 81-entry yield trial of dwarf-internode varieties grown at two locations in California, there were highly significant differences for oil content between locations and among varieties, however, the variety-location interaction estimate was non-significant. A previous estimate of a variety-year interaction of normal-internode varieties was also non-significant when years and varieties were highly significant. This suggests that selection for oil content at one location should be sufficient.

At Davis, California, pollen from three lines having detectable seed size differences was applied to racemes of pistillate N-145-4 plants. Sib pollination was included as the fourth treatment. Twelve replications were not quite sufficient to detect a significant xenia effect for index in the F_1 seed. However, the rank according to the pollen parent was nearly perfect indicating that, though present, the xenia phenomenon is of minor importance from the seed index standpoint. Its effect on oil content in F_1 seed is as yet unknown.

5. Sesame. The development of new varieties that retain their seed after maturity so that harvesting can be completely mechanized might be accomplished by using either of two characters presently known in sesame, indehiscence or strong placenta attachment. Indehiscent lines have been developed, but their capsules have been so hard that threshing has been difficult and seed damage has been high. Considerable progress has been made in breeding lines with capsules that remain closed, have improved threshability, and fewer of the deleterious characters associated with the indehiscent gene. Capsule size, both length and diameter, is associated with threshing percentage. The correlation between length and threshing percentage was 0.70 in the 1961 trials, and the correlation between capsule diameter and threshing percentage was 0.56. The best line had an average capsule size of 9.9 x 56 mm with a threshing percentage of

98. This compares favorably with a capsule size of 7.0 x 30 mm and 71 threshing percent. Twenty of the newer indehiscent lines produced excellent yields at College Station, Texas, and some of these excelled in capsule size, earliness, or the indehiscent character.

Strong placenta attachment offers promise of reducing shattering without the deleterious effects of the gene for indehiscence. Lines developed at College Station, Texas, averaged 82.3 percent seed retention in 1961.

Breeding of dehiscent sesame with seed types especially suited to the whole seed trade involves primarily rough seed coat type and large-seeded lines. Nineteen of 22 rough seed coat lines were not significantly different from Margo in yield or maturity in a preliminary yield test at College Station and some appear superior to Margo in one or more traits. Approximately a ton of seed of the rough seed coat line SI 72 was produced for processor evaluation. Of 37 large seed lines tested in a preliminary yield test at College Station, Texas, 29 were not significantly different from Margo in yield and only 6 were later in maturity than Oro. Seed of all these lines was larger than that of the standard varieties. The most promising sources of resistance to Race 2 of P. sesami are found among selections of the large seed x Early Russian cross or backcrosses to Early Russian; a few lines apparently combine resistance with determinate growth habit and good plant type and should be superior to Early Russian for transferring resistance to indehiscent types. A single plant selection from P.I. 170,733 produced significantly more seed (1,759 pounds per acre) than any other strain for the second consecutive year at Gainesville, Florida. This line has strongly upright branches, fairly large white seed, and some resistance to the leaf and stem diseases prevalent in the area.

6. Sunflower. Seed of two new hybrids was produced. The female parent of both is the self-incompatible line S 37-388; male parents are Beacon-9-2 (a short rust-resistant line) and Hopi-04-01-B1-3-1-2 (a short, vigorous, rust-resistant, ornamental type line) which should produce a branching-type hybrid that can be used to test the theory that a multiple-headed hybrid should have yield advantage. Some extremely short dwarf-internode lines have been isolated from dwarf x tall crosses. Self-pollinated seed was obtained from 41 dwarf segregates in the F_2 and F_3 generation of dwarf x Manchurian and Greystripe crosses; some of these selections have fairly large seed.

Among 51 introductions grown, the most interesting were the six high oil varieties developed in the USSR. These six introductions (P.I. 265,099 through P.I. 265,104) were compared with two experimental hybrids T 55,001 and T 56,002 in a replicated yield test.

T 56,002 produced the highest seed yield (1,702 pounds per acre). P.I. 265,100, P.I. 265,099, and P.I. 265,101 produced 1,085; 826; and 786 pounds per acre, respectively, which were not significantly different from the yield of T 55,001 (1,042 pounds per acre), the check strain at College Station for many years. Oil content of seed of T 56,002 and T 55,001 was 30.6 and 34.0 percent, respectively, while oil percentage of the Russian varieties varied from 39.6 for P.I. 265,104 to 46.4 for P.I. 265,099. Not only do these introductions have thinner seed coats and, therefore, a higher percentage of kernel (65.2 to 73.1) than the checks (58.6 and 59.2), but oil content of the kernel is also higher than that of the domestic hybrids. Fatty acid content of the oil of the eight yield test entries was determined by gas chromatography. Percentage palmitic acid (5.2 to 7.3) and stearic acid (2.2 to 3.6) were low and little variability was apparent. Oleic and linoleic acid content were high and quite variable; whenever oleic acid increased, linoleic acid decreased and vice versa. Linoleic acid content of P.I. 265,104 and T 55,001 was high (53.8 and 48.4 percent, respectively) and ranged down to 32.8 and 33.0 percent for T 56,002 and P.I. 265,099, respectively. The observed range of oil content from 30.6 to 46.4 percent and the range of linoleic acid content of the oil from 32.8 to 53.8 percent indicates that these characteristics should be susceptible to improvement by breeding. Since the F_1 hybrids, T 55,001 and T 56,002 have the same female parent, it may be inferred that the extreme difference in linoleic acid content of their oil is due to the genetic constitution of the male parents. If this is actually the case, a hybrid made by crossing the short-statured, rather self-sterile Russian variety P.I. 265,104 with the self-fertile inbred line Sunrise-9-7-2 (which is the male parent of T 55,001) ought to produce oil high in linoleic acid. Since these Russian varieties are all either highly or relatively self-sterile, it may be possible either to use them or inbred lines isolated from them as female parents of F_1 hybrids. In addition to the seed and oil characteristics noted above, these varieties are reported to be resistant to rust and to the larvae of the Russian head moth (Homoeosoma neubullela) in the USSR. It is not known whether they are resistant to the American races of rust or to the North American species of head moth (Homoeosoma electellum).

7. Tung. In an attempt to introduce the late-blooming habit of Aleurites montana into A. fordii, work with interspecific hybrids had continued. First, second and third backcrosses have been made and are being evaluated late blooming. Any trees that show this character will in turn be inbred to fix this character since tung is propagated from seed.

Late blooming individuals have also been found among seedlings of A. fordii and have been selfed and progeny grown to determine whether late blooming was a characteristic of the seedling or the result of

other factors. Several such seedlings and their progeny are under study. The most promising ones are as follows:

(1) L-152 selected at Folsom, La., in 1952. Good producer. Ranked high in 1960 and 1961.

(2) L-301. Selected in 1955 because it produced a crop when all others were wiped out in the March 25-26 freeze. Open pollinated seedlings show extended fruiting habit and fruit has high oil content.

(3) G-46. Selected in Georgia. Hybrids of other selections with G-46 have been made but have not been evaluated.

(4) Tree at Tupelo, Mississippi, 200 miles north of the tung belt, reported to have had consistent crops for 10 years. Seedlings are being evaluated.

(5) A late blooming tree at the Tungsten Plantation at Capps, Florida has again bloomed late and set a crop. Seeds have been obtained for further study.

(6) Tree at VanCise orchard, Albany, Ga. Tree bloomed in 1962 after all others were through.

It thus appears that variants within A. fordii offer good possibilities and should be amply tested.

The tree designated as L-301 has shown a new type of flowering--multiple buds. The first or apical one produces a flower cluster at normal blooming time. After 6 to 12 nodes have been extended on the vegetative shoot, another flower cluster develops and often this process repeats itself to produce a third flower cluster. A high proportion of the flowers set fruit. Fruits from the first and second level yielded the same amount of oil. Open pollinated seedlings of L-301 show the extended fruiting habit and are being evaluated for production and frost hardiness.

Seedlings grown from gamma ray treated pollen, seed and shoots have shown some malformations and will be watched for mutations. Irradiation of rapidly growing shoots seems to hold more promise than seeds or pollen.

Breeding appears to hold promise for the production of leaf spot-resistant material. A number of leaf spot-tolerant selections have been made and these in turn have been crossed with L-301 and other late-flowering types to combine the two desirable features. The highest leaf spot tolerance in the seedlings resulted from crosses of two tolerant parents and was less when one parent only was

tolerant. Insufficient data are available to indicate whether resistance is due to a single dominant factor or to multiple factors.

B. Diseases

1. Safflower. Rust, incited by Puccinia carthami, and root rot, caused by Phytophthora drechsleri, remained the principal disease problems of safflower. Verticillium wilt, Botrytis head rot, Alternaria leaf spot, virus diseases, and powdery mildew also were noted in 1962 and in particular areas certain of these diseases were potentially serious.

Varietal reactions to rust collections indicated the presence of additional races of P. carthami. A new and better source of rust resistance was found among recent safflower introductions. Progress was made in transferring rust resistance to commercial varieties. A technique of identifying mature leaf resistance in seedlings was developed. This technique may be of great value to breeders since it may be possible to test very large numbers of seedlings in flats and transfer the resistant plants to plots to be grown to maturity.

Proof of the existence of two pathogenic races of Phytophthora drechsleri was found. Breeding lines with resistance to both races as well as better seedling resistance than in commercial varieties were identified. Progress made in improving sporangia formation in P. drechsleri promises to aid precise screening for root rot resistance by standardizing zoospore numbers in inoculations. Thiamine and oxythiamine were shown to affect growth of P. drechsleri and their relation to varietal resistance is being studied. Nine of 12 different species of Phytophthora were shown to be pathogenic on safflower in preliminary tests.

2. Peanut. Large-seeded Virginia-type peanuts responded differentially in some respects and similarly in others when five standard commercial varieties were grown for 3 years at Holland, Virginia, in fields with a history of severe stem rot caused by Sclerotium rolfsii, under four combinations of initial land preparation and subsequent cultivation known to induce a wide range in level of incidence and severity of stem rot. Each year the combination of deep coverage of organic debris and cultivation in which no soil was thrown about the base of the plants effectively suppressed incidence and severity of stem rot and increased yield and market quality of pods of all varieties. Every year symptomatic reactions of two of the varieties was less severe than for others. Two years out of three, two varieties showed significantly less readily discernible infection than the other varieties. However, critical statistical evaluation of regressions showed that all five varieties responded similarly in yield to a given change in level of incidence of stem rot. Varieties showing least evidence of stem rot under conditions

highly conducive to development of the disease were not consistently the highest yielding varieties when the disease was effectively controlled by cultural procedures.

In 1961, Southeastern Runner 56-15, a small-seeded runner of the Virginia type, and Jumbo Runner, reported to be almost immune to stem rot, responded to stem rot and its control by cultural procedures in a manner comparable to that of the five large-seeded Virginias that have been under study from 3 to 7 years.

Spanish and Valencia-type peanuts, in test for the first time in 1961, showed a significantly higher level of incidence of stem rot under conditions highly conducive to its development and a proportionately greater response in increased yield from cultural control of stem rot than varieties of the Virginia type. The variety-stem rot study is being continued in 1962.

Deep coverage of organic trash and non-dirting cultivation effectively reduced stem rot and increased yield of peanuts in 1960 at Headland, Alabama, where during three previous seasons and in 1961, with little evidence of disease, no significant effects of these land preparation and cultivation procedures were apparent. In contrast with results in Virginia, deep coverage of surface trash was more effective in reducing disease and increasing yield than non-dirting cultivation. Deep coverage of surface trash and non-dirting cultivation resulted in one-half as much disease and 31 percent higher yield for Virginia Bunch 67 and about one-third as much disease and 48 percent higher yield for Early Runner, as compared to results where trash burial was poor and soil was thrown around the base of plants to control weeds.

The first cycle has been completed of a comprehensive cooperative field study at two locations in Georgia where corn, soybeans, cotton, and winter rye cover are grown in alternate years with Spanish peanuts to determine the cumulative effect, over a period of years, of the influence of the kind, amount, and distribution of organic litter in the soil on the incidence and severity of soil-borne diseases and on yield and market quality of pods. At Plains, Georgia, rye cover increased pod yield in a striking manner. At Tifton, Georgia, precision deep burial of surface trash sharply reduced soil-borne disease and increased pod yield as contrasted with ineffective trash burial; and both rye cover and corn residues resulted in less disease and higher pod yield than residues of cotton or soybeans. This study at Plains is cooperative with the Agricultural Engineering Research Division of ARS.

Water soluble plant extracts had a striking effect on growth of Sclerotium rolfsii in vitro in cooperative studies at Auburn, Alabama, involving extracts of clover, vetch, oats, corn, and peanuts. Clover extracts provided the best nutrient solution for

the growth of the fungus, followed in order by peanuts, vetch, corn, and oats, with the last two having a definite suppressing effect. Kind of solid plant residue influenced production of sclerotia by S. rolfsii in soil-sand mixtures. Significantly more and generally larger sclerotia were produced in a soil-sand mixture amended with corn and oats, with sclerotia yield and size decreasing in order with vetch, peanut, and clover residues. The effect of the different chopped residues on sclerotia production was the reverse of the effect of extracts of the same crop residues on growth of the fungus in liquid culture. Residues of oats and corn significantly suppressed germination of sclerotia of S. rolfsii when added to water-agar. Germination of sclerotia on water-agar to which chopped residue of clover, vetch, or peanuts was added was virtually the same as that on water-agar alone.

Observations and preliminary exploratory tests since 1955 at Holland, Virginia, had failed to provide any clue as to the identity of organism or organisms causing a destructive pod rot of peanuts in the Virginia-Carolina area or as to how the disease might be controlled under field, laboratory, or greenhouse conditions.

In 1961, results from heavy in-soil dosages of eight narrow-spectrum pesticides, known to be specific for the control of certain groups of microorganisms, and seven other materials used at Holland, in a field with a history of severe pod rot, provided preliminary evidence that the pathogen causing pod rot is a phycomycete, probably a species of Pythium. PCNB (pentachloronitrobenzene), currently recommended for control of stem rot in North Carolina and Texas, appeared to increase incidence and severity of pod rot whether used alone or in combination with other chemicals. Yield and market quality of pods tended to increase proportionately with degree of control of pod rot. Pod rot is considered to be the most destructive disease of peanuts in the Virginia-Carolina area for which no control is known. Studies of its cause and control are continuing with increasing emphasis in 1962.

An outbreak of "pepper spot," caused by Leptosphaerulina arachidicola was recorded on peanuts at Tifton, Georgia, in 1960. At Beltsville, Maryland, the outbreak was very severe in 1960, less severe in 1961. A general blight of peanuts, which has been a cause of concern for several years in New Mexico, is thought to be caused by this same organism. None of the numerous introductions, advanced breeding lines, and standard varieties of peanuts at Tifton or Beltsville was free of the disease. The effect of this "new" disease on yield and quality of the peanut crop has not been determined. No practical control for the disease is known.

Peanut rust, a disease limiting peanut production in the Caribbean, Venezuela, and other areas of South and Central America, which has

been observed sporadically in the southern part of the peanut belt in the United States for 40 years, is causing increasing concern in the United States. In recent years rust has approached epidemic proportions at times in restricted areas in Georgia, Alabama, and Texas, and has been frequently observed in Florida. In 1961, peanut rust was observed in North Carolina and Virginia several hundred miles farther north than previously. None of the numerous lines of peanuts exposed to rust in this country has shown detectable resistance to the disease. Little is known of peanut rust or the organism which causes it. Negotiations are in progress with the Federal Experiment Station, Mayaguez, Puerto Rico and the Centro de Investigaciones Agronomicas, Maracay, Venezuela for screening our large collection of peanut germplasm for possible resistance to the strain or strains of rust present in these countries.

3. Flax. Tarnished plant bugs (Lygus spp.) were found to cause toxicogenic injury to flax. When heavy infestations occur, flax fails to produce seed. Unusually high populations of this insect were noted in commercial fields in 1961.

Applications of MCPA (2-methyl-4-chlorophenoxyacetic acid) and TCA (trichloroacetic acid) herbicides to flax at recommended rates has been found not to affect the degree of wilt infection of flax when grown on wilt-infested soil. This result is contrary to that of previous preliminary studies of this nature.

Relative tolerance of varieties to pasmo (Septoria linicola) is associated with rate of spread from centers of infection, with lesion size and spores per unit of lesion area, and with wettability of leaves. The knowledge that the degree of tolerance is indicated by rate of spread has been utilized to good advantage in the breeding program designed to improve resistance to pasmo.

Band applications of phorate, a systemic insecticide, at 1 lb. per acre for the control of six-spotted leafhopper (Macrosteles fascifrons) significantly reduced aster yellows infection without causing phytotoxicity to flax seedlings.

Infection by aster yellows affects flax more adversely than does infection by crinkle virus--57 percent versus 23 percent reduction in seed production.

Selection through successive generations for resistance to aster yellows is not effective beyond a moderate level of resistance. To increase the latter, a program of hybridization between relatively tolerant lines with subsequent selection from segregating populations has been initiated.

4. Castorbean. Botrytis capsule mold and Alternaria leaf spot were the major diseases of commercial castorbeans. Varietal resistance was shown to control adequately both diseases in the present production areas.

Varietal resistance to Botrytis capsule mold was found to be related to amount of leachable sugar, to resistance to maceration by pectic enzymes, and to such plant characters as inflorescence compactness, position of staminate flowers, and internode length.

The use of a commercial pectinase enzyme as a capsule spray proved to be a rapid method of measuring varietal resistance to Botrytis capsule mold.

Considerable progress was made in developing varieties with resistance to post-maturity capsule drop, the principal disease and limiting factor of production in Mississippi. Desiccating and harvesting before the onset of this disease was most promising as a method of control.

5. Sesame. Diseases were important problems of production of commercial sesame. Bacterial leaf spot, caused by Pseudomonas sesami, was severe. Serious damage to Margo was caused by Rhizoctonia root rot in poorly drained fields. Verticillium wilt was prevalent. Alternaria leaf spot caused some damage to Margo in a seed field at Wilcox, Arizona.

Breeding lines and selections resistant to bacterial leaf spot were identified and used in crosses to incorporate resistance to this disease with suitable agronomic characters.

Resistance of certain sesame varieties to bacterial leaf spot appeared related to the ratio of reducing sugar to certain amino compounds present in the leaves. Resistance was expressed when leaves had a high reducing sugar content and a low content of the amino compounds. The pathogenicity of races of P. sesami was related to the glucose-asparagine ratios at which they would grow.

Control of bacterial leaf spot by seed treatment or the use of disease-free seed did not appear particularly promising but tests are being continued.

Good sources of resistance to Verticillium wilt and Fusarium wilt were identified among varieties, introductions, and breeding lines. Tests at Stoneville and Beltsville with a wide range of germplasm showed a lack of suitable resistance to Alternaria and Corynespora leaf spots when the diseases are epiphytotic. Under less severe conditions, some lines appeared to have sufficient resistance for production purposes.

6. Tung. Leafspot, the most important disease affecting tung, is caused by Mycosphaerella aleuritidis (cercospora), and in years favorable to the disease can cause serious losses. The fungus causes early defoliation and reduction in oil content. Basic and applied work is underway to develop effective control procedures.

Detailed studies of the fruiting habits of the fungus, and factors which affect infection have been made and the following basic information developed:

(1) Higher percentages of infection were found when spores were applied to the dorsal than the ventral sides of leaves.

(2) Infection took place at the same rate on old and young leaves when exposed at the same time, indicating no differential in susceptibility. The fact that old leaves on seedlings usually showed the first infection raised the question of greater susceptibility; it now appears that as the seedlings develop, the older leaves have had longer exposure, hence complete the necessary 30-day incubation period before later infected leaves.

(3) The generally greater severity of leaf spot in years of heavy crops has suggested that infection may be associated with excessive demand of carbohydrates or to weighting down branches and decreasing air circulation. Tagged shoots were defoliated to produce a leaf/fruit ratio of .7 as compared to the normal of 10.0, but a higher incidence of leaf spot on the normals would tend to indicate that aeration, perhaps in drying of leaves, is a more important feature of infection than carbohydrate reserves. However, girdled shoots were much less affected than those not girdled.

(4) Studies on spore discharge showed that rain is necessary for ascospore discharge. The highest number of ascospores caught on vasoline coated slides placed above old leaves on the orchard floor was in the first 6 hours following rain. However, once infection has taken place, greater damage to the tree results during drought. When trees have ample water they are able to retain infected leaves.

(5) The incidence of leaf spot was reduced on seedlings exposed in areas where old leaves had been burned or buried as compared to no sanitation, but once infection was established, the difference was soon obliterated. Sanitation alone will not control leaf spot.

(6) Seedlings exposed at varying distances up to 1 mile from an infected orchard all showed infection indicating that spores are easily carried by wind, further indicating that more than sanitation is necessary for control.

Various fungicide treatments have shown that oil is somewhat effective in reducing infection, but is also associated with early fruit drop. When fungicides such as Maneb, Captan, and Phygon were incorporated with oil, they failed to improve control over oil and some were very toxic. Aqueous solutions of fungicides will be used in 1962.

C. Varietal Evaluation

1. Safflower. Gila continues to lead all commercial varieties in the production of oil and is the variety usually grown on irrigated acreage because of its resistance to Phytophthora root rot. N-10 is the favored variety for non-irrigated areas although it does well under careful irrigation. N-4051, an experimental variety, has made excellent yields under irrigation, but has unsatisfactory oil and would be unacceptable to crushers.

2. Peanut. Range of adaptability of varieties, new introductions, and advanced breeding lines was studied in 48 regional tests during 1960 and 1961 in cooperation with State experiment stations at 15 locations in 9 States. As a result of such tests during the past few years, the range of adaptability of Starr and Florigiant, developed by the Texas and Florida experiment stations, respectively, and released in 1961, was known at the time of their release. In addition to Texas, Starr, a Spanish peanut of medium seed size, was known to be well adapted to production in Georgia and Oklahoma with a demonstrated yield potential in these States fully the equal of or slightly superior to Argentine. In addition to Florida, Florigiant, a large-seeded Virginia runner type peanut, was known to be well adapted to production in Georgia, Florida, Alabama, and Virginia, outyielding standard commercial Virginias in these States and showing less susceptibility to visible and concealed damage of seed under curing conditions conducive to development of appreciable damage in standard large-seeded Virginias. When grown under irrigation in the Delicias Region of Mexico in 1961, Florigiant outyielded all large-seeded Virginias.

Results of a preliminary study of range of genetic variability in chemical composition of peanut germplasm, involving 100 entries including 8 accessions of wild species of Arachis at Tifton, Georgia, indicate that sound mature seed of some lines may contain, on a quantitative basis, as much as 18 percent more oil or 30 percent more protein than others. A reciprocal relation appears to exist between oil and protein content of mature peanut seed. Over a 2-year period, oil content of mature seed ranged from 50 to 59 percent and protein from 26 to 34 percent. Composition of seed of wild species was intermediate to that of cultivated peanuts.

Since 1960, more than 2,000 new peanuts--introductions from foreign countries or selections therefrom--have been screened at Beltsville,

Maryland, for possible seedborne diseases new to this country and are in various stages of being characterized and evaluated for yield, suitability for the edible trade in their present form, or possible usefulness in breeding and in genetic studies designed to increase the efficiency of future breeding programs. More than 80 percent of these new peanuts appear to be either pure lines or mixtures of genetically stable lines. Special efforts are being made to expedite the identifying and evaluation of any lines among these new accessions which might be superior in yield to varieties now grown and suitable for the edible trade.

In preliminary yield trials at Holland, Virginia, in 1961, 25 percent of 425 of these new peanuts, involving Spanish, Valencias and Virginias of small to large seed sizes, outyielded standard commercial check varieties under conditions where average yield of checks ranged from 2,673 to 4,648 pounds per acre.

Some 130 new introductions will be screened at Beltsville in 1962 for possible seedborne diseases. Some 1,100 of the new peanuts screened at Beltsville in 1960 and 1961 are being grown in replicated yield trials in Alabama, Georgia, Oklahoma, Texas, and New Mexico in 1962. Some 250 additional new lines are being grown at Holland, Virginia in 1962 to provide sufficient seed for future replicated yield trials. Seed of 180 new accessions of Valencias, already screened at Beltsville, are being stored in 1962 pending opportunity for evaluation in replicated yield trials.

Negotiations are continuing for stocks of peanuts now grown in foreign countries that might be of interest and possible value in peanut improvement in the United States.

D. Cultural Practices

1. Safflower. Tests in Arizona and Nebraska indicate that early plantings are best. If late plantings are necessary, increased plant populations are needed to obtain maximum yield. Optimum time of planting in Arizona is between mid-November to late-December; in Nebraska, between April 15 and May 1 with local environmental conditions determining exact planting date. Optimum planting rate for early plantings should provide approximately seven to eight plants per square foot. Extremely early plantings in Arizona and late plantings in Nebraska tend to reduce percent oil content.

Rows spaced 7 inches apart appear to be better than wider row spacings in Nebraska tests. Narrow row spacing together with an early planting date appears to be the most favorable combination for highest yields.

Individual head samples and a windrowing study show that safflower

seed has reached maximum dry weight accumulation and percent oil content with 14 percent moisture at 31 days after an estimated 90 percent bloom. Maximum germination is found 14 to 16 days after anthesis although maximum seedling vigor is not obtained for at least another 7 to 10 days.

Near maximum yield (95 percent), weight-per-hundred seeds (91 percent), oil (96 percent), and test weight (95 percent) were obtained 24 days after 90 percent bloom at 25 percent moisture. Windrowing at this time could prepare the crop for threshing in 2 to 3 days with little loss in yield and oil. Windrowing appears to reduce seed spoilage without increasing shattering.

Air-dry seed placed in an oven at 125°, 150°, 175°, and 200° F. was reduced in germination by 3, 8, 67, and 100 percent, respectively. It is assumed that seed at higher percentage moisture would be more susceptible to viability damage from heat than air-dry seed. High temperatures also change refractive index of the oil so that estimation of iodine number by refractive index is unreliable.

Neither mechanical nor chemical weed control practices were as effective in 1961 as in 1960. Most effective cultural control in Nebraska was obtained by two rotary hoeings, the first 4 days before and the second 14 days after emergence of safflower seedlings. The use of EPTC (ethyl N, N-di-n-propulthiolcarbamate), EPTC + amiben (3-amino-2,5-dichlorobenzoic acid), and EPTC + CDEC (2-chloroallyl diethyldithiocarbamate) yielded only 14, 93, and 39 pounds more per acre than the untreated check plot.

Twenty-two chemical treatments plus a hand-weeded control, and an untreated check plot, were tested in cooperation with Weed Investigations--Agronomic Crops. The unweeded check produced only 550 pounds per acre, while the hand-weeded treatment yielded 1,016 pounds per acre. Highest yields from chemical treatments came from plots receiving EPTC. When EPTC was applied at 8 pounds per acre preplant, an average yield of 948 pounds was obtained. Injury to safflower was minor, while weeds were observed to be moderately affected.

2. Peanut. Fresh seed dormancy varied widely in new peanut introductions grown at Beltsville in 1960 and 1961, even among Spanish and Valencias, indicating the possibility of finding or developing desirable varieties of these two types of peanuts with sufficient fresh seed dormancy to prevent premature sprouting in the soil while pods are still attached to living plants.

Persistence of dormancy varied widely among "dormant" varieties in a 2-year study at Beltsville. Under conditions where pods were cured in 10 days to 2 weeks and placed immediately thereafter in storage

at 38 to 40° F., dormancy in several varieties dissipated quickly, but 4 out of 9 varieties of the 1959 crop still showed more than 20 percent dormant seed, with more than 55 percent for Dixie Runner, following 6 months of storage. For the 1960 crop, after more than 5 months of such storage, 1 variety showed 95 percent dormancy, 3 others showed more than 50 percent, and 3 additional showed more than 24 percent dormant seed among 19 varieties tested. These results have important implications with respect to possible use of continuous low temperature storage for seed peanuts.

Among standard commercial varieties which need to be checked for possible dormancy following rapid curing and low temperature storage of seed, are NC 4X, Virginia 56R, Virginia 61R, Dixie Runner, Early Runner, Virginia Bunch 46-2, Virginia Bunch G2, Virginia Runner G26, and Virginia Bunch 67. Seed dormancy dissipates rapidly in NC 2 and Florigiant and should not be a problem regardless of storage temperature.

Close rows failed to result in higher yield for Virginia Bunch 67 and Early Runner peanuts in 1960 and 1961 in a cooperative study in Alabama where rows were 12, 24, and 36 inches apart and seeding rate in the drill was constant at about one seed every 3.5 inches. This study is continuing.

Small immature seed resulted in small less vigorous plants early in the growing season and lower pod yields than Number 1 seed with Dixie Runner and Early Runner in Alabama where plants were thinned to a uniform stand 6 inches apart, or where 50 pounds of seed per acre were planted and no thinning done. Results indicate that use of small runner peanut seed for planting is of questionable value. Study is being discontinued and results are being summarized for publication.

Results at Beltsville in 1960 confirm previous findings that immature peanut seed are more sensitive to temperature during curing than mature seed. Viability of freshly dug immature seed of Virginia Bunch 67 peanuts was impaired by exposure of pods to a curing temperature as low as 95° F. as contrasted with mature seed which retained viability when cured at temperatures as high as 110° F. These results have implications with respect to use for planting of small peanut seed, most of which are immature to decidedly immature. An estimated 85 to 90 percent of peanuts grown in the Southwest and Southeast are now cured partially or entirely in windrows with varying proportions of the pods exposed to direct sunlight under conditions where air temperature around pods so exposed frequently exceeds 95° F.

3. Flax. Preliminary results from selecting within 6 populations at 4 levels of nitrogen fertility show differences in effectiveness of

selection for yield at different nitrogen levels. Further evaluations of selected lines will determine whether differences will persist when grown under different nitrogen levels.

Comparative fatty acid compositions of 24 flax varieties were similar whether grown at Fargo, N. D. or Morris, Minn., or in 1961 or 1962. Varieties considered to have excellent oil quality, such as Bolley or Marine, were comparatively high in linolenic acid and low in oleic acid. Conversely, varieties with poor quality oil were low in linolenic and high in oleic acid, irrespective of location or season grown.

The oil percentage of 20 flaxseed samples was found to be negatively correlated with seed density ($r = -.96$). The instrument used for seed density determination was an air comparison pycnometer which required about 6 minutes per determination. While samples of 20 grams gave best results, even smaller samples could be used. Seed density determination appears to be an effective, inexpensive procedure for screening large numbers of flaxseed samples for relative oil contents.

Field-grown seed from 16 "homozygous" plant lines of varieties, which are considered the extremes in linolenic acid content, were analyzed for fatty acid composition. High temperatures, particularly during the second and third weeks after flowering, cause increases in oleic acid and corresponding decreases in linolenic and linoleic acid, thereby lowering the quality of the oil.

A successful technique has been developed whereby immature flax seeds can be grown in vitro. This was verified by the detection of fat synthesis in vitro. Growing immature seeds in vitro will facilitate studies on (1) effects of small changes in environment upon fatty acid formation and on (2) biochemical pathways of fatty acid synthesis.

Techniques for investigating lipid metabolism in germinating flaxseed have shown (1) sodium hypochlorite to be a satisfactory surface sterilant, and (2) that for the determination of free fatty acids, dithio-oxamide is satisfactory to determine stearic acid, and a turbidometric assay is satisfactory for oleic acid. Thin-layer chromatography has been adapted to separating lipid materials, particularly oxygenated fatty acids, since the latter cannot be detected by gas chromatography.

Fatty acid composition of 35-day-old flax seeds was not affected by methods of drying; however, rapid drying of immature 7-day-old seeds resulted in different fatty acid composition than slow drying. The latter permitted interconversions to take place that resulted in decreases in palmitic acid and increases in proportions of linoleic and linolenic acids.

Oil content of seed samples of 0.12 to 1.2 grams was determined with satisfactory accuracy by a new technique that employs pressing and Soxhlet extraction. The new technique will greatly facilitate studies on fat metabolism in developing flax seeds.

Flax has been shown to be sensitive to its environment, particularly to (1) photoperiod, and (2) availability of essential linolenic and oleic acid. The lowest and highest percentages of linolenic acid were 27.4 and 63.6, respectively. Variation within lines, which can be attributed to environmental causes, was greater than expected, thus emphasizing the importance of research on the effects of environmental factors on fatty acid formation in flaxseed.

Combined application of the herbicides MCPA (2-methyl-4-chlorophenoxy-acetic acid) for broad-leaved weeds and dalapon (2,2-dichloropropionic acid) for grassy weeds, gave adequate weed control on an otherwise weedy field. However, dalapon caused different degrees of injury to the varieties. Marine was the most sensitive, Arny the least.

Three varieties of flax compared favorably with oats as companion crops for establishing alfalfa. Although the different cropping systems, including no companion crop, resulted in different stands of alfalfa the year of establishment, subsequent yields of alfalfa forage were not significantly different.

4. Castorbean. A water and fertilizer requirement test of Dawn and Baker 296 was conducted at Lubbock, Texas, with two moisture levels of 25 and 50 percent available moisture and five fertility levels of 0-0-0, 40-0-0, 80-0-0, 120-0-0, and 120-80-0 in a split-split plot design with four replications. This test was similar to those conducted from 1957 through 1960 except for the addition of the 40-0-0 treatment. Baker 296 was completely defoliated by Alternaria leaf spot in early September. There were significant differences in yield for the main effects of moisture levels and varieties with the 50 percent moisture higher than the 25 percent and Dawn higher than Baker 296. Dawn yielded more than Baker 296 for the fifth consecutive year. The 120-0-0 treatment produced the highest yields of the fertilizer treatments. A decrease in yield was noted with the addition of P_2O_5. This has been observed only once before in the previous tests at Lubbock, but a similar decrease was noted at Halfway, Texas, in 1960. The 50 percent moisture level and the 120-0-0 fertilizer treatment resulted in the highest yields for both varieties with Dawn yielding (2906 lb./A.) 52 percent more than Baker 296.

In preliminary field-scale fertilizer trials conducted on sandy soil southwest of Seminole, Texas, using sprinkler irrigation, the highest rate of fertilizer, 120-40-40, resulted in the highest yields for all varieties with Hale, Dawn, and Baker 296 yielding 2,681, 1,586, and 1,496 pounds per acre, respectively. At the 0-0-0 level,

all varieties averaged between 800 and 900 pounds per acre.

Eleven experimental dwarf-internode hybrids and one normal-internode hybrid were compared at four locations in the Sacramento Valley from Davis to Chico. Two locations were sub-irrigated and two were surface irrigated. Results showed castorbeans had good adaptation in this area. Variety-location interactions were observed for yield and test weight. Oil content was higher in the two sub-irrigated tests and remained high despite overall yield differences between them.

5. Sesame. Cultural tests have been conducted at Muleshoe, Texas, during the period 1958 through 1961 and at Lubbock, Texas, in 1960 and 1961. A review of the data from 10 separate experiments shows that the influence of number of rows per bed was the most consistent of the cultural treatments; two rows per bed produced significantly higher yields than a single row per bed in 6 of the 7 experiments in which these variables were compared. Among the interactions involving number of rows per bed, rows per bed x fertilizer treatment was significant in two of five tests; rows per bed x plant spacing within the row was significant in one of five tests; and rows per bed x varieties was significant in two of four tests (the two varieties interacted in reverse order in the two cases of significance). Fertilizer response was apparent in only one of seven experiments. A variety x spacing within the row interaction was apparent in only one of five tests.

A direct combine study was conducted at Lubbock, Texas, during the period December 26-30. Three indehiscent sesame strains were planted two rows per bed and grown under irrigation. A combine was modified to include 16 cylinder bars on the 12-inch cylinder. Approximate cylinder speeds of 800 and 900 rpm were used in this study. Triplicate combine samples of each strain were obtained from single beds 200 feet long. Combine tailings and ground losses were obtained in order that combine efficiency could be calculated for each strain. Duplicate hand-harvested samples were threshed with the modified Vogel thresher. SI 128 gave the highest combine yield of 706 pounds per acre for 800 rpm and 622 pounds per acre for 900 rpm cylinder speeds. SI 152 produced the lowest combine yield of 412 pounds per acre for 800 rpm and 386 pounds for 900 rpm cylinder speeds. SI 139 was intermediate in seed yield but gave the highest combine efficiency of 90.9 percent for 800 rpm and 94.0 percent for 900 rpm cylinder speeds. Combine efficiency for all three strains was higher than the comparable threshing percentage value obtained from hand-harvested Vogel-threshed samples. Also, higher seed yields were obtained by direct combining at 800 rpm cylinder speed for all three strains than when measured hand-harvested samples were threshed by the modified Vogel thresher. The seed injury, as measured by germination tests, was comparable for both methods. Hand-harvested and hand-threshed samples for the three strains germinated 67 percent (a mean value for the three strains) while

the combine seed samples germinted 43 percent and the samples obtained from Vogel harvesting germinated 41 percent. This study indicates that indehiscent sesame can be direct combined with a high degree of efficiency several months after frost. However, the seed had been so severely weather damaged before harvest that it would have been impossible to produce high quality seed even if the threshing operation caused no damage at all.

A study designed to evaluate the effectiveness of CIPC [isopropyl N-(3-chlorophenyl) carbamate] for pre-emergence weed control in sesame was conducted in cooperation with Weed Investigations--Agronomic Crops, at Stoneville, Mississippi. Rates consisted of 6, 8, 10, 12, 14, 16, 32, and 0 pounds per acre. The variety Oro was planted and treatments of CIPC were applied in a 20-inch band on May 24. All rates of CIPC provided excellent annual weed control with essentially no visual injury to sesame. However, yield data obtained indicate the possibility of some plant injury from CIPC treatment since all treated plots produced lower seed yields than the untreated check. There was no statistical significant difference in the yield of the untreated check plot and those receiving 8 and 12 pounds of CIPC per acre; all other treatments produced significantly lower yields than the check.

6. Tung. Tung is grown on a wide variety of soils with different pH, water-holding capacity, and nutritional levels, necessitating more information on nutritional requirements, tree spacing, timing of fertilization, cover crops, etc.

At Compass Lake, Florida, tree spacings of 5 feet as compared to 10 feet in the row at 8 years of age produced 2.8 and 1.9 tons, respectively, per acre. The closer planted trees had 15 percent less trunk cross sectional area per tree but 71 percent more per acre due to the greater number of trees. The closer planted trees have produced a total of 7.5 as compared to 4.8 tons for the 10-foot spaced trees but the advantage is dropping annually. This demonstrates the feasibility of closer planting and removal of alternate trees at about 10 years of age.

At Compass Lake, extensive fertilization plots have shown variable effects of nitrogen when applied in different forms and in combination with other elements. High rates of N increased CSA but when combined with high rates of zinc, decreased CSA. When high N, supplied as ammonium nitrate was combined with high K, CSA was increased regardless of the level of zinc. Increasing N or K increased the level of both of these elements in the leaves. The addition of lime or gypsum appeared to remedy leaf burn (probably a calcium deficiency) but increase magnesium deficiency.

At White Sands, Mississippi, on fine sandy loam, N/K ratio experiments indicate that 0.1 pound of nitrogen per tree per year of age

up to 10 years and a ratio of K to N of 1:1 is the maximum application which will give economical returns. At Compass Lake, Florida, split applications--half in March and half in June--gave increased yields over all applied in March.

At Agricola, Mississippi, in a cultural treatment, fertilizer level experiment, plots in crimson clover receiving four spring cultivations yielded 2.5 tons, those in clover with one cultivation 2.2 tons, those in Bahiagrass with one cultivation 2.1 tons, and those in Bahiagrass without cultivation 1.7 tons. Trees receiving the recommended fertilizer rate yielded 2.3 tons, whereas those receiving half this amount yielded 2.0 tons.

Basic information is needed on the factors which influence fruit bud setting, dormancy, oil percentage in fruit, and various other physiological reactions in tung. Biochemical studies have been initiated to study and relate these processes. Extracts of predominantly staminate buds are being compared with those of fruiting buds in an effort to determine factors responsible for fruiting. Proline was found to be low during spring and early autumn but to increase during winter and thus perhaps is related to dormancy.

At Bogalusa, Louisiana, extensive work is underway to find chemicals which will prolong dormancy after tung has had its chilling requirement. The response of germinating seed and young seedlings has been utilized to speed up the work and provide a year-around source of test material. Maleic hydrazide delayed flower bud formation on mature trees and gave a corresponding reduction in growth in seedlings in proportion to concentration.

For some studies, it is still desirable to rely on the direct reaction of floral response. Previously it has not been possible to get flower buds to force on cut terminals. New results have shown that if terminals are brought from the field and re-cut under water and stored in water at near 32° with all but the terminal bud submerged, they can be maintained in good condition for months and can be forced by bringing them into favorable temperature.

Buds from tung sprayed with maleic hydrazide at 2,000 ppm on February 14, 1961, opened 3 to 4 days after normal and at 6,000 ppm, 5 to 6 days late. This delay, however, did not prevent injury from a front on March 10, 1961. When maleic hydrazide was used during the growing season, growth was stopped and with 9,000 ppm, oil percentage of the fruit was reduced 50 percent.

E. Replacement Crop Introduction and Evaluation.

1. Breeding Stock Introduction. The major emphasis of the plant introduction program is currently directed toward providing a broad base of germ plasm of potentially new oilseeds and breeding stocks of existing oilseed crops. Direct explorations were undertaken in South Africa, Mexico, and southern United States for plants for agronomic and utilization screening and provided 552 oilseed collections.

An exploration in Brazil, Paraguay, and Peru resulted in 125 collections of peanut breeding stocks, and 263 peanut lines were obtained through exchange from Southern Rhodesia. Seventy-two sesame lines from Greece and miscellaneous collections of safflower and soybean were also procured for crop specialists.

The oilseed and pulp screening programs have identified some 39 new leads which merit further agronomic and utilization study. These have been recommended to the 4 regional programs to be grown during 1962. Field collecting of Limnanthes, a potential oilseed, commenced in March 1962 with the objective of assessing the distribution of the desired fatty-acid constituent among the several species which are native to the California-Oregon region.

An intensive field survey and collection of Lesquerella for screening as a new oilseed crop was accomplished in southeastern and southwestern U. S. Nearly 300 pounds of seed were collected from wild stands for chemical studies on the seed oil and meal residue.

2. New Crop Evaluation

The new flax variety, 'Caldwell,' released jointly by Texas A&M College and USDA, resulted from pure-line selections made from hybrids involving the winter flax variety (P.I. 76794) introduced from the Netherlands in 1928. Its cold tolerance is superior to that of standard varieties. This variety is characterized by short, strong plants which produce good yields.

3. Chemurgic Crops

In the program for evaluating potential new crops that were selected for study on the basis of their chemical or fiber characteristics, the following salient progress was noted:

Crambe abyssinica has shown encouraging crop potentials as a source of erucic acid in the seed oil. Experimental plantings at a variety of sites show wide adaptation and ease of culture. Estimated yields of 1000-2000 lbs./A were obtained in many parts of the U. S. and utilization research indicates wide useage of the erucic acid constituent.

Field trials in Texas, Nebraska, and North Carolina demonstrate that Vernonia anthelmintica is a potential new crop. This plant is a source of epoxy fatty acid contained in the seed oil. Cultural details of planting and harvest have been experimentally established and yields determined. Major difficulties exist as a result of the long period of flowering and seed shattering.

Experiments conducted at Chico, California, on the crop development of Dimorphotheca, a South African genus with seedoils of high industrial value, have provided data on fertilizer and irrigation requirements and species variation. Disease problems still remain the major block to successful culture. A close relative, Osteospermum ecklonis, appears promising in plant habit, flowering time, and seed character.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Breeding

Hammons, R. O. 1962. Artificial cross-pollination of Arachis hypogea with bee collected pollen (Abstract). Georgia Agron. Absts., No. 5-1962, p. 9 (Mimeo).

Martin, A. L. D., Frederiksen, R. A., and Wesdahl, P. H. 1961. Aster yellows resistance in flax. Can. Jour. Pl. Sci. 41: 316-319.

Merrill, S., Jr., and Kilby, W. W. 1961. Breeding for a late-blossoming tung tree. Proc. Tung. Ind. Conv. 28: 12, 30.

Merrill, S., Jr., and Kilby, W. W. 1961. Progress in hybridizing Aleurites fordii with A. montana. Proc. Amer. Soc. Hort. Sci. 78: 225-229.

Zimmerman, D. C. 1962. The relationship between seed density and oil content in flax. Jour. Amer. Oil Chemists 39: 77-78.

Diseases

Boyle, L. W. 1961. The ecology of Sclerotium rolfsii with emphasis on the role of saprophytic media (Invitational paper for symposium on S. rolfsii of Southern Division Amer. Phytopath. Soc., Birmingham, Ala. Feb. 1, 1960). Phytopathology 51: 117-119.

Boyle, L. W. 1961. The results of persistent application of several cultural schemes for peanuts. Georgia Agr. Res. 2 (4): 10-11, 15.

Boyle, L. W. and Hauser, E. W. 1962. The relation between the response to sesone and development of root rot in peanuts. Weeds 10 (2): 106-111.

Covey, R. P. 1962. Field resistance of flax to pasmo (Abstract). Phytopathology 52: 6.

Flor, H. H. 1961. Complementary gene action in the rusts. Rec. Adv. in Bot. 1: 574-579.

Garren, K. H. 1960. Comparative development of stem rot in a Virginia bunch and a Virginia runner variety of peanuts (Abstract). Phytopathology 50: 575.

Garren, K. H. 1961. Control of Sclerotium rolfsii through use of cultural practices (Invitational paper for symposium on S. rolfsii of Southern Division Amer. Phytopath. Soc., Birmingham, Ala., Feb. 1, 1960). Phytopathology 51: 120-124.

Kilby, W. W., van der Zwet, T., Potter, G. F., and Lewis, W. A. 1961. Experimental control of tung leaf spot during 1960. Amer. Tung News 12 (6): 8-10.

Luttrell, E. S. and Boyle, L. W. 1960. Leafspot of peanut in Georgia caused by Leptosphaerulina arachidicola. Plant Dis. Rptr. 44: 609-611.

van der Zwet, T. 1961. Significance of the ascigerous stage of Mycosphaerella aleuritidis in the primary infection of tung in 1960. Phytopathology 51 (9): 646.

van der Zwet, T. 1961. Historical review of Mycosphaerella leaf spot diseases of Aleurites. Proc. La. Acad. Sci. 24: 81-88.

Zimmer, D. E. 1961. Powdery mildew of safflower. Plant Dis. Rptr. 45: 944.

Variety Evaluation

Comstock, V. E. 1961. "Flax" in varietal trials of farm crops. Minn. Agr. Expt. Sta. Misc. Rpt. No. 24, rev., pp. 15-18.
Culbertson, J. O. 1961. Registration of improved flax varieties, VIII. Agron. Jour. 53: 401-402.

Culture

Kilby, W. W., and Sitton, B. G. 1961. Effects of varying levels of fertilization and cultivation on production and returns from the tung orchard. Proc. Tung. Ind. Conv. 28: 8-9.
Neff, M. S., and Danielson, L. L. 1961. Control of grasses and other weeds in a tung orchard with herbicides, 1960-1961. Proc. Tung. Ind. Conv. 28: 10, 11.
Sitton, B. G., and Kilby, W. W. 1961. Delaying blossoming of tung trees. Proc. Tung. Ind. Conv. 28: 11, 12.
Sitton, B. G., and Lewis, W. A. 1961 (rev.) Chemical control of briars, volunteer tung seedlings, and other broad-leaved weeds in tung orchards. CR-CA-72-61, 3 pp.

New Crop Evaluation

Mikolajczak, K. L., Miwa, T. K., Earle, F. R., Wolff, I. A., and Jones, Q. 1961. Search for new industrial oils. V. Oils of Cruciferae. Journ. Amer. Oil Chem. Soc., 38(12), pp. 678-681.

Vanetten, C. H., Miller, R. W., Earle, F. R., Wolff, I. A., and Jones, Q. 1961. Hydroxyproline content of seed meals and distribution of the amino acid in kernel, seed coat, and pericarp. Ag. and Food Chem., 9(6), pp. 433-435.

WEED AND NEMATODE CONTROL
Crops Research Div., ARS

Problem. Weeds cause losses in crops, orchards, grazing lands, forests, water supplies, and irrigation and drainage systems. The losses caused by weeds can be reduced by finding more effective chemical, biological, mechanical, cultural and combination methods of weed control. Improved weed control methods will facilitate farm mechanization, increase production efficiency, and improve the efficiency of the use of human and land resources in agriculture.

Plant-parasitic nematodes occur in all soils used for growing of crop plants and attack all kinds of plants grown for food, forage, fiber, feed, or ornamental purposes. It has been long known that severity of attack by certain fungi is greatly increased if nematodes are present; and nematodes have been known to be the vectors of several plant viruses. There is a need for improvements in the methods of controlling nematodes by crop rotations, cultural practices, chemicals, and biological methods on oilseeds and peanuts.

USDA PROGRAM

Much of the weed control research in the Department is cooperative with State Experiment Stations,other Federal agencies, industry and certain private groups, and is cross commodity in nature. The total weed control program involves 64.6 professional man-years' effort. Of this total 2.4 is specifically directed to weed control in oilseeds and peanuts at Stoneville, Mississipppi; experiment at Tifton, Georgia; Temple, Mesa, and Yuma, Arizona. The Federal scientific effort devoted to basic and applied nematode research is 23.5 professional man-years, of which 1.9 is devoted to applied research in oilseeds and peanuts at Auburn, Alabama; Tifton, Georgia; and Jackson, Tennessee.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Information on the weed and nematode research for commodities by State Experiment Stations and industry is not available. For a summary statement covering all research by these agencies on weed control, see pages 240 and 241; and on nematode control, see page 276, in the Crops Research Division Report.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Weed Control.

a. Soybeans. In weed control studies in soybeans at Stoneville, Mississippi, amiben continued to be the most effective pre-emergence herbicide in this crop. Diuron plus a surfactant applied as a directed spray was the most effective post-emergence treatment evaluated to date. Herbicides used to control heavy weed infestations resulted in yield increases, lower trash content and fewer damaged beans.

Research conducted in the Mississippi Delta has demonstrated that 4-(2,4-dichlorophenoxy)butyric acid [4-(2,4-DB)] will provide excellent cocklebur control and adequate control of pigweed at a cost of less than $1.00. The herbicide need not be applied until the weeds become a problem and then can be applied with conventional spray equipment.

b. Peanuts. Results at Experiment, Georgia, indicated that infestation from nutsedge tubers (Cyperus rotundus L.) planted equidistantly in either one or three foot spacings was very rapid especially during the first ten weeks after planting. At the end of one growing season, there was 75 percent as many plants in the area with original three foot spacings as in the area with tubers planted in one foot spacings.

Life cycle studies with nutsedge at Experiment, Georgia, indicated that (1) no dormant tubers formed during the first six weeks after foliar emergence; (2) tuber chains or fully mature rhizomes were not observed until the tenth week or long tuber chains until the 18th week; (3) after the sixth week, the subterranean parts weighed more than the foliage; and (4) rhizome length and the number of tubers and bulbs increased throughout the season even through periods of decreased foliar vigor.

Also at Experiment, Georgia, one application of amitrole was made on different plots of nutsedge at biweekly intervals throughout the growing season. The results indicated that (1) nutsedge was most susceptible to amitrole four weeks after initial foliar emergence and next most susceptible at one or two weeks, (2) amitrole apparently prevented tuber formation during the period of its activity, and (3) growth of nutsedge and responses to amitrole were variable among plant systems grown from individual tubers.

Research at Tifton, Georgia, showed that low rates of DNBP, in mixture with either sodium 2,4-dichlorophenoxyethyl sulfate (sesone) or with tris(2,4-dichlorophenoxyethyl) phosphite (2,4-DEP), gave much better weed control than either material used alone. Combinations of DNBP-sesone or DNBP-2,4-DEP have given full season control of annual weeds.

At Experiment, Georgia, the use of herbicide mixtures provided a definite advantage over individual herbicides for good weed control and safety to peanuts, but not in soybeans or safflower.

c. Other Oilseed Crops. At Tempe, Mesa, and Yuma, Arizona, studies have shown that pre-emergence applications of herbicides are effective in controlling broadleaved weeds in safflower without adversely affecting yield. The most outstanding compounds were EPTC and CIPC.

Further studies with the World Collection of lines of flax at St. Paul, Minnesota, showed that tolerance and susceptibility to the herbicide 2-methyl-4-chlorophenoxyacetic acid (MCPA) were genetically controlled characters. Studies are being conducted to determine how MCPA tolerance and susceptibility are inherited.

B. Nematode Control.

Oilseeds and Peanuts. Experiments at Jackson, Tennessee, in cooperation with the Tennessee Agricultural Experiment Station, have shown that crop yield decreases due to the soybean cyst nematode can be eliminated by treating the soil prior to planting with moderate amounts of standard nematocides, but that even very large applications of nematocides did not kill all of the nematodes in small experimental plots. When soybeans grown on infested soil, were rotated with several kinds of non-susceptible crops such as cotton and corn, yields of soybeans every other year or every third year approached normal, but attempts to grow two successive crops of soybeans nearly always resulted in failure of the second crop. The Peking variety of soybeans were found to have a high degree of resistance to the nematode, no larvae having been recovered from soil after three successive crops. The nematodes were found to reproduce well on mung beans and common lespedeza, but rather poorly on snap beans. Hatched larvae of the soybean cyst nematode survived only a few days in soil under field conditions, but larvae in cysts can apparently survive for years in the field, or for at least a year when stored with soybean seed. In temperature tests, larvae and eggs in cysts were killed in less than a second at 145° and in less than 10 seconds at 140°.

Experiments at Jackson, Tennessee demonstrate that soybeans heavily infected by the soybean cyst nematode often are deficient in the nodules formed by nitrogen bacteria, and the addition of

inoculum of the bacteria to the soil or to the seed does not correct the deficiency. Soil fumigation to kill the nematodes or nematode-reducing rotations may improve nodulation.

In experiments at Auburn, Alabama, in cooperation with the Alabama Agricultural Experiment Station two populations of the "peanut root-knot" nematode (Meloidogyne arenaria) were found to differ greatly in their ability to infect and develop on peanuts.

At Beltsville, Maryland in experiments in temperature tanks, it was shown that susceptibility of certain soybean varieties is influenced by soil temperature.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Weed Control

Hauser, E. W., Shaw, W. C., Harrison, H. F., and Parham, S. A. 1961. An evaluation of herbicidal mixtures for weed control in peanuts. (Abstract) Proc. SWC, pp. 118-119.

McRae, G. N., Hamilton, K. C., and Arle, H. F. 1961. Evaluation of soil applications of herbicides for controlling weeds in safflower. Res. Prog. Rept. WWCC, pp. 71-72.

McWhorter, C. G. 1961. Soybean weed control in the Mississippi Delta. Soybean News, 13, pp.3-4.

Peters, Elroy J. 1961. Pre-emergence weed control in soybeans. Res. Rept. NCWCC, p. 61.

Nematode Control

Dropkin, V. H., and Nelson, P. E. 1960. The histopathology of root-knot nematode infections in soybeans. Phytopathology. 50(6):442-447.

Endo, B. Y. 1961. Desiccation studies on the soybean-cyst nematode, Heterodera glycines under controlled humidity conditions. Phytopathology. 51(9):643.

Endo, B. Y. 1962. Survival of Heterodera glycines at controlled relative humidities. Phytopathology. 52(1):80-88.

Endo, B. Y. 1962. Responses of Heterodera glycines to lethal temperatures. Phytopathology. 52(1):9.

Epps, J. M. 1961. Evaluation of crop rotations and soil fumigation for controlling the soybean-cyst nematode. Phytopathology. 50(9):635.

Epps, J. M., and Chambers, A. Y. 1962. Effects of seed inoculation, soil fumigation, and cropping sequences on soybean nodulation in soybean-cyst-nematode-infested soil. Plant Disease Reporter. 46(1):48-51.

Epps, J. M., and Chambers, A. Y. 1962. Effects of seed inoculation, soil fumigation and cropping sequences on nodulation of soybeans grown in soybean-cyst-nematode-infested soil. Phytopathology. 52(1):9.

SOIL AND WATER MANAGEMENT AND CONSERVATION
Soil and Water Conservation Research Div., ARS

Problem. The importance of soil and water conservation in the nation's agriculture can hardly be overestimated. Without these natural resources there would be no agriculture - no crops - no food - no fibers--the nation's very existence is dependent on its soil and water resources. The development of improved tillage, crop residue management, fertilization, drainage and irrigation practices requires not only a knowledge of soil and climatic factors, but also widely varying moisture, temperature and nutrient requirements for establishment and growth of different crops.

Each crop and each physiographic area presents specific problems on soil and water management and conservation. For some crops the problem is excessive moisture at seeding. For other crops, adequate moisture must be provided at seeding. High soil temperatures are critical for some crops, whereas low soil temperatures are the major problem for other crops. For legumes, proper inoculation may be a problem. Consumptive use of water, water use efficiency and proper timing of moisture and fertilizer, applications need further study for various crops. In studying these various factors, different crops are used as tools to measure soil and water research responses.

USDA PROGRAM

The Soil and Water Conservation Research Division has a continuing program doing basic and applied research and employing 17 disciplines to increase knowledge in all phases of soil and water management and watershed engineering. The total professional man-years involves 416 trained and specialized workers. Estimates of professional man-years are not available by commodities.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 20.3 professional man-years of which 1.0 were engaged in research on oilseeds and peanuts.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Oilseeds and Peanut

At the U. S. Soil, Plant and Nutrition Laboratory at Ithaca, New York, during the past year, three additional γ-glutamyl dipeptides have been isolated in crystalline form and their identity conclusively proven by comparison with synthetic dipeptides. Soybean seeds were the source of the two other isolated dipeptides. These compounds have been shown to be γ-L-glutamyl-L-tyrosine and γ-L-glutamyl-L-phenylalanine. The identity was conclusively proven by comparison with synthesized dipeptides. The tyrosine dipeptide has not previously been reported to exist in plants although the phenylalanine peptide has been isolated from onion bulbs.

It is noteworthy that there was about 500 times as much -alanine in the dipeptide form than unbound in the iris tissue. An analogous situation is found in soybeans where there was twenty-seven times as much tyrosine and seven times as much phenylalanine in the dipeptide form as in the free form.

Two greenhouse water-culture studies in which soybean seedlings were sprayed with a solution of 200 p.p.m. of the growth retardant Amo 1618 have been completed. The osmotic pressure of the tissue fluids was of primary interest as a putative factor in the increased salt tolerance of treated plants. The osmotic pressure of leaf saps was consistently lower in Amo-treated plants, averaging 0.3 atm. less than the control leaves in five determinations made at intervals during the week following the spray treatment. The osmotic pressure of stem- and root-saps, on the contrary, tended to be higher for the plus-Amo than the control plants by a like amount. Although a definite effect of this retardant on osmotic pressure of tissues is indicated, the effect appears too small to account for the large difference in response to abrupt salination reported by Marth and Frank. Stem elongation during the week following Amo-treatment was affected by the retardant amounting to a 42 percent reduction in the treated plants compared to the control.

In a second experiment, Amo-treated and untreated cultures were subjected to three salinity levels (0, 1.5, and 3.0 atm. added sodium chloride) from May 29 through July 3. The growth retardant caused a 43 to 51 percent reduction in top growth at the three salinity levels, with a marked increase in leaf-stem ratio over the controls, indicating again the pronounced effect on stem elongation which for the amo-treated plants was only 26 to 32 percent of the controls at the three salinity

levels. Salinity caused approximately the same percent reduction in top growth for the Amo-treated plants as for the nontreated ones. In this test, the growth-retardant effects of Amo 1618 and salinity were, therefore, additive, and salinity exerted as great a growth-depressive effect on the Amo-treated plants as on the controls. The osmotic pressure of leaf sap was again slightly depressed by the Amo-treatment in the absence of salinity but was higher under saline conditions. Stem osmotic pressures were consistently higher for the plus-Amo cultures, while root osmotic pressures showed no significant effect of Amo-treatment. The usual effects of salinity on osmotic pressure of all organs were also apparent. The results to date indicate that osmotic-pressure changes in the plant may favor an increased resistance to abrupt changes in the osmotic pressure of the medium but that tolerance to a continuing state of salinity is not increased thereby. In fact, growth (and presumably yield) reflects the depressive influence of both salinity and retardant. Further studies are contemplated with a variety of retardants and treatment levels.

Iron is more often deficient in plants than any other minor nutrient element. At the Pioneer Laboratory on Mineral Nutrition, Beltsville, Maryland, the compounds keeping iron in a soluble form in plants have been identified. Soybeans were used in some of these studies. Exudates were collected from normal and iron deficient plants. The combination of iron was established by electrophoresis and found to be chiefly with two plant acids, malic and malonic. The varying capacities of roots to reduce iron before it has been absorbed has been demonstrated. After the iron enters the plant it is again oxidized.

Preliminary results obtained by field studies in 1961 indicated that most of the nodules formed on soybean plants grown in areas with a large population of soybean organisms are formed from those already in the soil and not from the inoculum. This emphasizes the need for selecting highly competitive and high nitrogen-fixing strains for use as inocula. This problem has been attacked by classifying the rhizobia into serological groups and by taking advantage of the fact that many strains of soybean nodule bacteria produce chlorosis.

At Auburn, Alabama, in an experiment to determine the factors involved in root development in subsoils with low pH values and high levels of exchangeable aluminum, it was found that soybean roots were quite tolerant, cotton roots moderately tolerant, and sudangrass roots very sensitive to these subsoil conditions. Marked improvement in sudangrass root development in acid subsoils resulted from liming. In all cases the surface soil environment was favorable.

The results of studies to provide insight into the mechanism by which growth retardants increase the tolerance of soybeans to high fertilizer applications indicates that osmotic-pressure changes in the plant may favor an increased resistance to abrupt changes in the osmotic

pressure of the medium but that tolerance to a continuing state of salinity is not increased thereby. In fact, growth reflects the depressive influence of both salinity and retardant. Study of the dynamic aspects of osmotic-pressure adjustment in plants confirms the importance of potassium in effecting short-term osmotic adjustments. Salinity stimulates the potassium increase during the day, but even during the first day of adjustment, other ions may begin to displace potassium in effecting a steady-state adjustment to salinity.

Studies in North Carolina with controlled water tables and plant environment showed that growth of soybeans was inversely proportional to depths to water tables that ranged from 6 to 36 inches when the controlled ambient temperature was 72° F. At 80° F., growth was directly proportional to depth to water table, and at 90° F., growth was not affected by depth to water table. Leaf temperature of soybeans was not affected by water table depth.

In South Carolina, soybeans planted directly in grain stubble and corn planted directly in Coastal Bermudagrass gave yields equal to those on conventionally prepared seedbeds.

Safflower production in nonirrigated regions of the Great Plains area depends primarily on the supply of available soil moisture. Weed-free safflower plots at the Sidney, Montana station have produced about twice as much seed as nonweeded plots. It is recommended that the chemicals, Proban and Monsanto 17029 be tested again on a small plot basis in 1962. The rate of application should be increased for Proban, since it has shown no injurious effect of safflower. Monsanto 17029 should be tested again at about the same rates of application, and both chemicals should be applied when the weeds and safflower crops are very small.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

None.

SOYBEAN AND PEANUT INSECTS
Entomology Research Div., ARS

Problem: Soybeans and peanuts are severely damaged by several insect pests in the different areas where these crops are grown in the United States. The increasing concentration of acreage in soybeans and possibly the adaptation of native insects to this crop are resulting in more varied and more serious insect problems. In the absence of specific support for research on soybean insects, some shifts in emphasis have been made to investigate some of the problems. However, basic information is lacking on the biology of many of these pests and on the extent and nature of damage they cause to these crops. Such information is needed to serve as a foundation for the development of satisfactory control methods. Some insecticides, although highly effective in controlling insects on soybeans and peanuts, cannot be used because they leave harmful residues. Further, certain insects have developed resistance to insecticides that are currently recommended. For the immediate future, there should be continued effort to find insecticides that can be used safely and that give effective, economical control of all species of insects attacking these crops. For more desirable long-range solutions to the problems, more attention needs to be given to nonchemical control methods, with particular emphasis on insect-resistant crop varieties and biological control agents and the exploration of new chemical approaches such as attractants and repellents.

USDA PROGRAM

The Department has a limited program involving basic and applied research on the insect problems of peanuts and soybeans directed toward developing efficient and economical control methods. The program is cooperative with State and Federal entomologists, agronomists and chemists. Studies on soybean insects are conducted at Columbia, Mo., and on soybean and peanut insects at Tifton, Ga., in cooperation with the Missouri and Georgia Experiment Stations.

The Federal scientific effort devoted to research in this area totals 1.5 professional man-years. Of this number 0.4 man-year is devoted to basic biology, physiology, and nutrition; 0.5 to insecticidal and cultural control; 0.5 to insecticide residue determinations; and 0.1 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 3.0 professional man-years divided among subheadings as follows: Basic biology, physiology and nutrition 0.6, insecticidal and cultural control 1.8,

insecticide residues 0.4, and varietal evaluation for insect resistance 0.2. State stations are studying the biology of stink bugs, armyworms, and the grape colaspis on soybeans and means to control these pests. In the Virginia-North Carolina peanut area, State stations are conducting research with new insecticides for rootworm control on peanuts, because this insect has developed resistance to formerly effective insecticides, and on residues in peanut kernels and hay. Selection and testing of peanut varieties for rootworm resistance are also underway.

Industry and other organizations contribute to the research effort on soybean and peanut insects. Chemical companies make significant contributions on synthesis, analysis, formulation, and primary screening of insecticides, which are discussed in another area, and conduct limited field testing of insecticides against insect pests of soybeans and peanuts. Soybean and peanut producers supply fields of soybeans or peanuts in which tests may be conducted. Estimated annual expenditures of industry, exclusive of grants and cooperative agreements to State or Federal stations, are equivalent to approximately 1 professional man-year.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Basic Biology, Physiology and Nutrition

1. Soybean Insects. In screen-cage tests at Columbia, Mo., during 1961, the period of maximum damage to soybeans by the brown stink bug Euchistus servus occurred during the four-week period following bloom. Most damage took place in the last half of this period and declined noticeably thereafter. The total number and weight of beans, and the number of pods produced, were not significantly different for three 2-week infestation periods following bloom. Most of the damage occurred in the lower third of the plants and significant differences due to time of infestation were confined almost exclusively to this area.

To evaluate damage to soybeans in relation to various densities of brown stink bug infestation, screen cages were placed in field plots and infested with one, two, three, and four pairs of the insect. The number of immature or underdeveloped soybeans was significantly higher than the check at all rates of infestation. The immature seeds from the middle third of the plants showed significant differences from the check plots as well as between the treatments themselves, except between treatments consisting of 2 and 3 pairs of insects per cage. Stink bugs confined in cages containing six soybean plants damaged approximately 5 seeds per plant per bug. The germination of soybean seeds was reduced in relation to the number of stink bug punctures per bean. Beans from check plots

showed 98-99% germination while those receiving 1, 2, 4 and 8 or more stink bug punctures per bean germinated at 93, 91, 81, and 37%, respectively.

Determination of oil and protein content of five commercial varieties of soybeans damaged principally by the green stink bug, Acrosternum hilare, revealed a decrease in oil content and an increase in protein content. It is believed that this condition is directly related to the size of the bean rather than to any significant tissue damage. As seed size decreases the amount of seed coat tissue increases in proportion to the oil bearing endosperm. Thus, stink bugs may indirectly affect oil and protein content by causing the production of smaller seeds.

B. Insecticidal and Cultural Control

1. Soybean Insects. Stink bug damage to five commercial varieties of soybeans grown at Columbia, Mo., decreased as the planting dates became later after April 19. Considerable variation in damage was observed between varieties within planting dates but all damage from stink bugs was reduced as planting dates were extended through May into mid-June.

At Tifton, Ga., Sevin, Guthion, diazinon, endosulfan and dimethoate were applied to soybeans at 1 pound per acre when the pods were small and the plants still blooming to determine control of the velvet bean caterpillar, the fall armyworm and the Mexican bean beetle. Insect populations were light but in all treatments they were lower than in the check. Differences were not significant, however, except for the velvet bean caterpillar and the Mexican bean beetle in the counts taken two weeks after application. Endosulfan gave best control of the velvet bean caterpillar, followed by Guthion, Sevin, dimethoate and diazinon. Dimethoate gave best control of the Mexican bean beetle, followed by endosulfan, Sevin, Guthion and diazinon. Since an infestation of the fall armyworm did not develop in the test area, 4-day old laboratory-reared larvae were fed 1-inch leaf discs from the treated plots. While all materials caused mortality of the larvae, diazinon, Guthion and Sevin were the most promising.

C. Insecticide Residue Determinations

1. Soybean Insects. At Tifton, Ga., dimethoate was applied at 4, 8 and 16 ounces per acre in an emulsion spray to soybean foliage suitable for harvesting as hay. Plant samples taken 1 day after treatment showed residues of 5.86, 7.06, and 7.96 p.p.m. for the 4-, 8- and 16-ounce treatments, respectively. On the 8th day after treatment the residues were .026, .052 and .110 p.p.m.

2. Peanuts. Peanuts were grown at Tifton in soil treated with broadcast and row-band applications of aldrin at 1-1/3 pounds per acre and heptachlor at 2 pounds per acre in 1960. Soil residues from the two types of treatment, respectively, at harvest, 4 months after planting, were 0.10 and 0.16 p.p.m. heptachlor; .06 and .03 p.p.m. heptachlor epoxide; 0.20 and 0.31 p.p.m. aldrin; and 0.14 and 0.24 dieldrin. Residues of heptachlor (0.15 and .04 p.p.m.), heptachlor epoxide (0.10 and .02 p.p.m.), aldrin (.02 and .02 p.p.m.) and dieldrin (0.36 and 0.17 p.p.m.), were found on the vines at harvest. Peanut hulls showed .06 and 0.20 p.p.m. heptahclor, 0.18 and 0.38 p.p.m. heptachlor epoxide, .01 and 0.10 p.p.m. aldrin and 0.33 and 1.70 p.p.m. dieldrin. The peanut meats contained residues of heptachlor (.08 and 0.38 p.p.m.) and heptachlor epoxide (0.68 and 1.34 p.p.m.) from the heptachlor treatment, and aldrin (0 and 0.11 p.p.m.) and dieldrin (0.72 and 1.91 p.p.m.) from the aldrin treatment. In 1961 peanuts were planted on the same soil and harvested in October, 17 months after the insecticide treatment. Residues of aldrin plus dieldrin on the whole unwashed nuts were 0.11 and 0.13 p.p.m., and of heptachlor plus heptachlor epoxide, .07 and .02 p.p.m., for the broadcast and row band treatments, respectively.

These data indicate that soil treatments of granular aldrin and heptachlor at rates of 1-1/3 to 2 pounds per acre when made at planting time will result in residues on the forage, peanuts, and in the meats at harvesttime.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

None.

PEST CONTROL TECHNIQUES AND EQUIPMENT, HARVESTING, AND HANDLING OPERATIONS, CROP PREPARATION AND FARM PROCESSING
Agricultural Engineering Research Div., ARS

Problem. Many pests attack oilseeds and peanuts resulting in dollar losses to farmers each year. Plant diseases, weeds, insects and nematodes are examples. Every method to control or eradicate any of these pests requires some type of equipment, be it a small chemical sprayer or a giant bulldozer. In many situations, effectiveness of the equipment necessary may be essential to the success of the method which is attempted or recommended. Thus, equipment to control a wide variety of pests on a wide variety of crops is required. There is a need for improved methods of much greater efficiency for applying pesticides to plants and the soil.

Development of equipment and methods for efficiently harvesting and farm handling oilseeds and peanuts, with emphasis on the preservation of inherent qualities during these processes is needed. The cost of harvesting and farm handling of most crops is the major expense of production, often amounting to over half of the total returns to the producer from the sale of the product. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory.

While research on harvesting equipment and methods has led to much improvement in the reduction of production costs of some crops, much additional work needs to be undertaken, both basic and developmental, in order that all crops may be mechanically handled.

Development of better methods, techniques, and equipment for use on farms for the initial preparation for market or the processing of oilseeds and peanuts is needed to increase efficiency in the use of labor and equipment, preserve quality and prevent spoilage and damage from mechanical handling. While considerable information has already been obtained for the development of processes such as drying and separation, basic and more precise information must be developed for these and other processes before development progress can be continued. The underlying principles that pertain to the cleaning and drying of different crops, curing of

peanuts, and sorting need to be determined. The methods for processing farm crops are largely dependent on production practices and dictated by future handling or storage requirements. Consequently, this requires interdisciplinary collaboration in the creating of a completely mechanized program of crop production.

USDA PROGRAM

The Department has a continuing long-term program involving agricultural engineers, physicists, and mathematicians engaged in both basic studies and the application of known principles to the solution of farmers problems. Pest control research on soybeans is conducted at Columbia, Missouri, and at Ames, Iowa. The research for peanuts is at Holland, Virginia. The Federal scientific effort devoted to research in this area totals 0.8 on soybeans and 0.2 on peanuts.

The Department has a continuing long-term program involving agricultural engineers engaged in both basic and applied research on the engineering phases of crop harvesting and handling. Research on oilseeds and peanut harvesting equipment and methods is cooperative with the Experiment Stations at Stillwater, Okla., (castor beans); Bogulsa, La., (tung nut); and Holland, Va., (peanuts). The Federal engineering effort devoted to research on oilseeds and peanuts harvesting and handling operations and equipment totals 3.6 professional man-years.

The Department's effort in the area of crop preparation and farm processing (except cotton) constitutes a long-term program involving agricultural engineers and statisticians engaged in both basic and applied research on the engineering phases of crop preparation and farm processing. Research on the drying and hulling of tung nuts is conducted at Bogalusa, Louisiana, in cooperation with the Experiment Station and industry. The Federal engineering effort devoted to research in this area totals 0.2 professional man-years.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 1.2 professional man-years in the area of crop harvesting and handling operations and equipment. Oilseeds and peanut harvesting studies are underway in the Southern, Western, and North Central Regions.

In the area of crop preparation and farm processing the State Experiment Stations in 1961 reported a total of 1.1 professional man-years on curing of peanuts.

Industry and other organizations conduct engineering research on equipment and methods for the harvesting of crops. Both full line and small manufacturers cooperate in USDA research through loan of equipment. Farm operators and organizations furnish land, equipment, and facilities for evaluation of experimental harvesting equipment. Much of the industrial experimental development of harvesting equipment is highly confidential and is generally not made available to public researchers. Estimates are not available on annual expenditures for research on oilseeds and peanuts.

Industry and other organizations concerned with crop preparation and farm processing devote their research effort to equipment and methods for use in the fields of drying and seed cleaning. Both full line and small manufacturers cooperate in USDA research through loan of equipment. Since industry relies primarily on public agencies for basic research in this area, considerable interest, encouragement and cooperation is given by industry. Farmers and organizations furnish crops, equipment and facilities for experimental use.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Pest Control Techniques and Equipment.

1. Weed Control in Soybeans. In Missouri in 1960, a pre-emergence treatment of 20 lbs. per acre of Na PCP plus cultivations as needed was the best combination of mechanical and chemical weed control and gave the highest soybean yield over a four-year period.

Field studies were conducted in Missouri in 1961 on the effect of shields, row spacings and other combinations of mechanical and chemical weed control practices. Shielding soybean plants while spraying the weeds with 1-1/2 lbs/A of 2,4-D amine was no better than the same treatment without shields. Studies were made to determine the effect of row spacing on Clark soybean yields with and without pre-emergence treatments of amiben at a rate of 3 lbs/A. With 24-, 32-, and 40-inch row spacings, the amiben was less effective in controlling weeds than was two cultivations without amiben. With 8- and 16-inch row spacings amiben was quite effective in controlling weeds without cultivation.

Studies were continued in Iowa in 1961 to evaluate various granular herbicide formulations and to develop methods and equipment for accurate and efficient application. Pre-emergence studies on soybeans continued to show that granules were as effective as liquids. Studies were made to determine the number of granules required per unit area of soil surface for effective weed control. Using 2,4-D ester granules of various sizes showed that 0.3 granules per square inch were as effective as 5.2 granules per square inch when measured in terms of number of surviving weeds in mid-June.

Studies of the metering characteristics of granular herbicides were continued in 1961 with tests of some of the common granular applicators. Results indicate that the fine granules tend to move to the bottom and the coarse ones to the top of the hopper as the applicator is operated. With most of the commercial applicators, the amount of material discharged from the applicator did not vary directly with the speed of the agitator so that relatively constant field speeds are required for accurate metering. An error of about 10% in discharge rate due to inaccuracy of the metering device was common with the granular applicators used. An experimental screw type metering device was tested and found to vary in feed rate directly with the screw speed. However, the discharge was pulsating rather than a desirable steady flow.

A nozzle test stand was developed in 1960 so that spray nozzles could be accurately calibrated. Results from calibration studies show that a 10% difference in discharge rate between nozzles of the same size from the same manufacturer is not uncommon.

Basic studies of rotary hoe performance were continued at Minnesota. (The rotary hoe is used for cultivation and weed control.) Values of vertical and horizontal operating forces on rotary hoe teeth were computed using certain assumed relationships between displacement and forces and found to agree well with measured values of these forces obtained from strain gage dynamometers. Operating forces required to maintain a constant operating speed and depth of penetration were found to vary considerably with the design of the tooth. There is no consistent relationship between the magnitude of vertical and horizontal operating forces and the operating characteristics of rotary hoes having different tooth configurations as measured by the quantity of soil disturbed. The quantity of soil disturbed was found to be an indicator of the effectiveness of the rotary hoe for cultivation and weed control and was found to be greatly influenced by tooth configuration.

2. Pest Control Equipment for peanuts. In virginia stem rot control practices involving ridge planting and non-dirting cultivation were compared with results from ridge and furrow planting with dirting cultivation. Only the ridge planted treatments received a herbicide. In an area of light stem rot infestation ridge planted and non-dirting cultivation had 0.5 percent of the plants infected with stem rot, 187,000 weeds per acre requiring 46 man-hours of hoeing labor, and yielded 1,873 pounds of peanuts per acre; ridge planted and dirting cultivation had 2.4 percent stem rot infected plants, 43,000 weeds per acre requiring 23 man-hours of hoeing labor and yielded 2,330 pounds per acre; furrow planted and dirting cultivation had three percent stem rot infected plants, 41,000 weeds per acre requiring 25 man-hours of hoeing labor and yielded 2,359 pounds per acre. In an area considered to be infected with stem rot the above practices showed: Ridge planted, non-dirting had 0.6 percent infected plants, and yielded 2,030 pounds per acre; ridge planted, dirting cultivation had 3.8 percent infection, and yielded 2,536 pounds per acre; furrow planting and dirting cultivation had nine percent plant infection, and yielded 2,788 per acre. These results showed dirting treatments had higher stem rot infection but higher peanut yields in locations when stem rot incidence was low. Weed and grass control without covering or damaging the peanut vines is a major problem in peanut production.

Studies continued on cultural practices incorporating combinations of herbicide applications and mechanical control resulted in variations on effectiveness of weed control and hoeing requirements. During an unusually high rainfall period, hand hoeing requirements ranged from 11 man-hours per acre when treated with a post-emergence application of herbicide (Dinitro) and cultivated close to rows to 46 man-hours per acre when treated with a pre-emergence application of herbicide (Dinitro) and not cultivated close to rows. In this rainy season six pounds of Dinitro applied per acre as a post-emergent reduced weed infestation by about one-half when compared with nine pounds of Dinitro applied as a pre-emergent. Two applications of Dinitro, with the second application applied in granular form have for the second consecutive year been so effective in weed control that no hand hoeing was required. Highest yields came from those treatments having the least weed infestation.

B. Oilseed and Peanut Harvesting and Handling Operations and Equipment.

Oilseeds and Peanut Harvesting Equipment. Harvesting the tung crop by the present method of hand gathering is the major cost in production. A complete harvester was designed, constructed, and operated

successfully harvesting 60 acres of well-prepared land with very low field losses. The machine is mounted onto a tractor and utilizes the tractor three point hitch for carrying a 1,000 lb. capacity low cost pallet-type box. Features include making its own windrow or picking up one made by other machines, removal of loose leaves and sticks, and delivery of cleaned fruit to a box mounted onto the tractor. The capacity of the harvester averaged about two tons cleaned fruit per hour. The removal of leaves using a large rotating perforated barrel set at an incline with a large volume of air blown upward through the barrel permitted separations not previously obtainable with other types of cleaners. A large portion of the sticks were also removed by the conveying system. Several tests showed the harvested fruit to have 3.3 percent foreign material.

A self-propelled windrower is needed to speed up tung harvesting operations where tree row width and/or low yields would result in operating the harvester at partial capacity on a small windrow. A windrower employing rubber fingers mounted as a helicoid on a cylinder was built and operated satisfactorily on 60 acres. This extremely maneuverable machine is built low to operate near tree trunks. Future studies will be to develop a blower on the windrower to clean out the tree row. This is needed to replace hand raking in the tree row area.

A bulk handling system for reducing costs and labor requirements of tung is needed to facilitate mechanical harvesting. Wooden wire-bound pallet type boxes were designed to have one side panel hinged which could be readily unlatched for dumping. The boxes which have a capacity of 1,000 lbs. of unhulled tung are picked up and hauled from the harvester and dumped into a trailer at roadside using a fork lift on a tractor. This system of handling harvested tung fruit required only one man on short hauls. Constant use of the boxes indicated certain structural weakness, however.

Defoliating castor beans as a means of conditioning to harvest is needed to lengthen the harvest season and to permit earlier harvest at a time when good weather is normally experienced. Past grower experience has shown defoliation with chemicals to vary in effectiveness when used at different times of the season. Defoliation studies were initiated in 1961 in cooperation with ARS, CRD, at Davis, California. A commercial high clearance sprayer was modified to include features for applying chemicals under a wide range of conditions suitable for field plot research. One year's results on both dwarf and normal internode plants showed the use of 1 quart Diquat with 20 gal. water and an activator applied at the rate of 20 gal.

per acre gave effective drying and conditioning of castor plants from August 23 through October 6. Later defoliation applications were not made due to wind loss of seed from the plants. Defoliating castor beans before September 21 prevented some of the spikes from maturing and consequently reduced yields and test weight.

Lower cost, more efficient castor harvesters suitable for use at high ground speeds are needed to increase growers' returns. Field loss studies on two current commercial model castor harvestors showed the major loss to be from the header. This amounted to 4.6 percent at 1.4 miles per hour and increased to 11.9 percent at 4.8 miles per hour. Improvements made to simplify castor harvesters which included sloping of the row brushes across the row, removal of one auger per row, and relocation of the rotating knockers resulted in two manufacturers incorporating these principles on their production machines.

An inertia-type beater employing high frequency low impact action was designed and built onto a castor bean harvester for the purpose of investigating more effective methods for removing castor bean capsules from standing plants. Brief tests in late winter showed the beater design has insufficient lateral movement for the mechanism to contact all plants, particularly those leaning out of the row line.

Two-drum hullers used on castor harvesters usually leave more capsules unhulled than other type hullers but have the advantage of operating without requiring precleaning to remove sticks and trash. Basic studies were made to evaluate factors affecting drum huller performance using a wide range of drum speeds, rates, and clearances. An analysis of tests showed that feed rate had no significant effect on the percentage of seed broken or the percent of oil bearing material removed in the trash. High feed rates caused significantly more unhulled seed than low feed rates. Drum clearance was found to have the most significant influence of the variables tested. Small clearances caused significantly more broken seed and significantly more oil bearing material in the trash sample than large clearances. Large clearances resulted in significantly more unhulled seed and also significantly reduced the rate of hulling. Because of the large percentages of broken and unhulled seed, drum hullers of a size used in this study need further development to be of optimum value on field harvesters.

Oily residue build-up on bulk conveying and harvesting equipment at temperatures of 60° F. or lower resulting from broken and oily castor seed will result in added seed breakage, also stops for clean out, and a decrease in conveying capacity. Previous studies showed conveyor housing temperatures of 100° F. were required to prevent build-up at low outside temperatures, although build-up did occur on the auger flighting. Current studies of heating the auger flighting with heating cable attached to the underside resulted in the auger remaining clean of residue build-up when kept at a temperature of approximately 90° F. at a time when outside temperatures were in the 40's.

A machine suitable for plot harvesting was designed and built as a research tool for the Agronomists to assist in developing improved varieties of castor beans better suited for mechanical harvesting.

Performance tests on a relatively simple low capacity huller-cleaner recently developed on the project for use on small scale or foreign country hulling operations showed that power requirements exceeded what could be sustained by manual operation. Effective cleaning was obtained at a feed rate of 500 lbs. per hour. The use of a positive air cleaning system instead of negative air cleaning employed in the present huller showed more effective cleaning.

Digger-shakers in common use result in losses of peanuts separated from the vines during digging. In addition, only a partial removal of soil from vines reduces the field drying rate. Further development studies on an experimental digger-shaker consisted of redesigning, increasing the number, and relocating elliptical-shaped kicker wheels that would permit more effective soil removal from the vines. Digging blades were widened and designed to cover the full width of two rows. Field tests showed recovery yields were higher on the experimental digger as compared to the conventional diggers. One hundred forty-four lbs. more peanuts per acre with a value of $15.00, and 305 lbs. more peanuts per acre with a value of $30.40 were obtained on two separate farms.

Accelerating the rate of field drying of peanuts by reducing the number of days exposed to the weather can mean material savings to the grower in peanuts saved, as well as quality retained, particularly during wet harvest seasons. Experimental methods to achieve a faster field drying rate of peanuts were continued. The percent of moisture remaining after 6 days of favorable drying weather in the windrow for

methods tested was as follows: placing windrow on a vapor barrier sheet, 20 percent (W.B.); windrowed with nuts up, 24.9 percent; windrowed with nuts mixed in windrow (conventional method of digging and shaking), 27.8 percent; clipping vines with rotary cutter, 27.8 percent; dessicant applied to vines, 28.6 percent; windrowed with nuts down, 30.1 percent. Optimum moisture content of peanuts harvested from windrows is considered to be approximately 8 percent.

C. Crop Preparation and Farm Processing.

Drying and Hulling of Tung Nuts. Tung is grown in a high rainfall area and this often results in prolonged periods of wet weather before the crop is harvested. Studies using an experimental drier were continued to determine the economic aspects and requirements of artificially conditioning tung fruit for safe storage on the farm. Elimination of air channeling and uneven drying was overcome only when tung fruit had all leaves, trash, and dirt removed. Additional basic data is being accumulated to assist in establishing the relationship of tung moisture content to drying requirements; moisture removal rate per unit of air flow; tung depth resistance to air flow, etc. These studies are to be continued.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Pest Control Techniques and Equipment.

Day, C. L., and Gebhardt, M. R. Dec. 5, 1960. Shields for Minimizing Plant Damage when Spraying for Weed Control in Soybeans, Paper No. 60-604, presented at the American Society of Agricultural Engineers Winter Meeting at Memphis, Tenn.

Gebhardt, M. R. February 22, 1961. Calibrating a Farm Sprayer. Abstract published in Proceedings of the First Annual Agricultural Chemicals Short Course, University of Missouri, Columbia, Missouri.

Lovely, W. G. April, 1960. Granular Weed Killers and How to Apply Them. FARM STORE MERCHANDIZING.

Lovely, W. G. December 5, 1960. Application of Granular Insecticides. Paper No. 60-619, presented at the American Society of Agricultural Engineers Winter Meeting at Memphis, Tenn.

Duke, G. B., and Garren, K. H. 1960. Planting, Cultivating Methods Will Affect Yield and Quality. Virginia Carolina Peanut News, Vol. 6, No. 5.

Miller, Lawrence I., and Duke, G. B. September, 1961. Peanut Nematode Disease Control. Virginia Agricultural Experiment Station Bull. 520.

Smith, E. S., and Duke, G. B. May, 1960. Recovery and Cultivating Peanuts for Stem Rot Control. Virginia Agricultural Experiment Station Cir. 852.

Oilseeds and Peanut Harvesting and Handling Operations and Equipment.

Bouse, L. F. 1961. A Study of Castor Bean Harvesting Field Losses. Oklahoma Agricultural Experiment Station, Processed Series P-372, March.

Culbertson, J. D., Johnson, H. W., and Schoenleber, L. G. 1961. Producing and Harvesting Seeds of Oilseed Crops. Yearbook of Agriculture.

Jezek, R. E., Kilby, W. W., and Schoenleber, L. G. 1961. Current Tung Machinery Research Studies. Proceedings of the 28th Annual Convention Tung Industry, Poplarville, Mississippi, September.

Schoenleber, L. G. 1960. Machines for New Crops. Yearbook of Agriculture, pp. 434-439.

Schoenleber, L. G. 1961. A Castor Bean Plot Harvester. Oklahoma Agricultural Experiment Station, Processed Series P-378, April.

Schoenleber, L. G. 1961. Mechanization of Castor Bean Harvesting. Oklahoma Agricultural Experiment Station Bulletin B-591, November.

II. UTILIZATION RESEARCH AND DEVELOPMENT

REPLACEMENT CROPS UTILIZATION POTENTIAL

Eastern Utilization Research and Development Div., ARS

Problem. Farmers could achieve economic use of their land if new and profitable crops were available that would have different end uses than crops presently grown. For example, it would be advantageous to develop a new oilseed crop yielding unique fatty acids that could find industrial use in applications for which acids from presently available domestic oilseed crops are unsuitable.

To develop a new crop, three basic steps are involved (1) survey of wild plants, in cooperation with plant scientists, to identify those having both potentially valuable components and promising agronomic potential for use in the U.S.; (2) detailed physical and chemical characterization of components of interest to obtain clues to likely end uses; (3) selection of the most promising species, followed by additional utilization research to explore uses and demonstrate industrial potential and by additional agronomic research to establish proper cultural practices and select the best strains and varieties.

Only after these steps have been successfully accomplished can a proposed new crop be offered to agriculture and industry for introduction and development. Obviously, a program of this type is a long-range one. Yet such long-range research is necessary if agriculture and the nation are to benefit from availability of the best practical crop plants.

To achieve this objective, survey and characterization work needs to be greatly increased, since the greater the number of species examined, the greater will be the opportunities for finding plants meeting the criteria of high utilization and agronomic potential. Work of the Department has already revealed several promising sources of new potentially valuable water soluble gums, pulp fibers, and oils containing unique fatty acids such as hydroxyunsaturated acids, capric acid,epoxy acids, and unusual long-chain fatty acids. In order to demonstrate the potential of these new materials, further work is required on their physical and chemical properties and reactions, on processing to obtain maximum recovery from source plants and on byproducts from processing, such as oilseed meals.

USDA PROGRAM

The Department has a continuing program involving chemists engaged in both basic and applied studies directed to the development of profitable new crops.

At Wyndmoor, Pennsylvania, work goes forward on the assay of Canaigre tubers for their tannin content and of Dioscorea tubers for their content of steroidal sapogenins, which are intermediates in the synthesis of corticoid drugs. This work is cooperative with the Crops Research Division.

Also at Wyndmoor, research work is carried out on the utilization of oil containing epoxy fatty acids, from the seed of Indian ironweed (Vernonia anthelmintica). This work is cooperative with the Northern Utilization Research and Development Division, the Crops Research Division and the Western Utilization Research and Development Division. The Federal scientific effort at Wyndmoor Totals 5.0 professional man-years. Of this number, 2.0 are devoted to composition of Dioscorea and Canaigre, and 3.0 to utilization of oilseeds containing epoxidized oils.

During this report period, work on the analysis of spices, that had been conducted by fellows supported by the American Spice Trade Association, was terminated.

Related programs of all State Experiment Stations, and industry and other organizations is reported by the Northern Utilization Research and Development Division in that Division's Summary of Current Program and Preliminary Report of Progress.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Assay of Dioscorea and Canaigre.

In this reporting period, assays of 661 agronomic samples of Dioscorea were carried out, substantially all of them Dioscorea spiculiflora, which is the species of choice as a potential replacement crop because of its gentrogenin content. Gentrogenin is a good starting point for the synthesis of many drugs. The assay results were reported to the Crops Research Division for consolidation with the agronomic studies of that Division.

Analysis of 225 samples of canaigre tubers from the 1961 crop, together with analysis of earlier samples, have established the existence of strains which contain over 40% tannin and which yield extracts with purities over 70. This work has established the usefulness of canaigre as a domestic source of vegetable tannin--necessary in the manufacture of heavy leather--but at present prices canaigre cannot compete with imported quebracho. Hence the most promising strains are being maintained in germ plasm banks; three new planting sites have been selected in the Tonto National Forest, and 3 high-tannin, high-yielding varieties were planted in quantity to permit rapid expansion in case of emergency. The germ plasm banks also include 183 selected strains that have potential for future breeding or propagation studies.

B. Utilization of Oilseeds Containing Epoxidized Oils.

The seed of Indian ironweed (Vernonia anthelmintica Willd.) contains 25% of a unique oil, which is rich in esters--principally the triglyceride--of vernolic acid (Epoxyoleic acid, $CH_3(CH_2)_4$ - $CHCHCH_2CH{=}CH(CH_2)_7COOH$). These esters represent 70-75% of the oil, expressed as the triglyceride. The oil is easily obtained from the seed by solvent extraction; when the extract is cooled to low temperatures, trivernolin can be recovered in good yield (60% of the oil) and high purity (95%).

The unmodified oil, trivernolin, vernolic acid and the barium and cadmium salts of vernolic acid all stabilize polyvinyl chloride against heat and light. Methods have been developed for the preparation of methyl vernolate in good yield and high purity by transmethylation of either the oil or pure trivernolin. This ester should also be a good stabilizer for vinyl plastics.

The oilseed contains enzyme systems which bring about chemical reactions in the oil. Preliminary experiments indicate that the activity of these enzymes may be controlled to produce free vernolic acid, 1,3-divernolin and (plus) threo-12,13-dihydroxyoleic acid.

This work was described at scientific meetings and several papers are now in the process of publication.

C. Analysis of Spices and Spice Oils.

Under the fellowships supported by the American Spice Trade Association, an analysis system was devised, employing gas chromatography and infrared spectrophotometry, for detecting in spice oils components. that are characteristic of the geographical origin. Three characterizing components were identified for black pepper, four for nutmeg, four for ginger and two for cassia. The ratios of gas chromatogram peak heights of these components were characteristic of the geographical origin of the spice.

This work has now been terminated.

PUBLICATIONS AND PATENTS REPORTING RESULTS
OF USDA AND COOPERATIVE RESEARCH

Assay of Dioscorea and Canaigre.

Kenney, H. E., Serota, S., Weaver, E. A., and Wall, M. E. 1960. Steroidal sapogenins. LVII. 11α-Hydroxylation of tigogenin derivatives. J. Am. Chem. Soc., 82, pp. 3689-3691.

Levine, S. G. and Wall, M. E. 1960. Steroidal sapogenins. LVI. The preparation of 12-methyl sapogenins. J. Am. Chem. Soc., 82, pp. 3391-3395.

Rothman, E. S. and Wall, M. E. 1960. Steroidal sapogenins. LIX. Conversion of 3β-acetoxy-5,16-pregnadiene-11,20-dione to intermediates in the 5-androstene series. J. Org. Chem., 25, pp. 1396-1399.

Rothman, E. S., Perlstein, T. and Wall, M. E. 1960. Steroidal sapogenins. LXIV. C-21 Acetoxylation of 12-keto steroids. J. Org. Chem., 25, pp. 1966-68.

Serota, S., Koob, R. P. and Wall, M. E. 1960. Steroidal sapogenins. LXIII. Chiapagenin, a new normal (25L) delta^{5}-12β-hydroxysapogenin. J. Org. Chem., 25, pp. 1768-1770.

Walens, H. A. and Wall, M. E. 1961. Steroidal sapogenins. L. Conversion of 12-ketosapogenins to 11β,12β-epoxypregnanes. J. Org. Chem., 26, pp. 1243-48.

Wall, M. E., and Fenske, C. S. 1961. Steroidal Sapogenins. LXI. Steroidal sapogenin content of seeds. Economic Botany, 15, pp. 131-132.

Wall, M. E., and Serota, S. 1960. Steroidal sapogenins. LXII. 12-Methyl hemiketals derived from 12-keto-16-dehydropregenes. Tetrahedron, 10, pp. 238-243.

Wall, M. E., Perlstein, T. and Levine, S. G. 1960. Steroidal sapogenins. LXV. Hydrogenation products of 3β,20-diacetoxy-5α, delta$^{16,20\ (21)}$-pregnadiene-12-one. J. Org. Chem., 26, pp. 159-61.

Wall, M. E., and Walens, H. A., and Tyson, F. T. 1961. Steroidal sapogenins LXVII. Preparation and stereochemistry of 20α-hydroxycyclopseudoneosapogenins. J. Org. Chem., 26, pp. 5054-5058.

Wall, M. E., Garvin, J. W., Willaman, J. J., Jones, Q., and Schubert, B. G. 1961. Steroidal sapogenins LX. Survey of plants for steroidal sapogenins and other constituents. J. Pharm. Sci., 50, pp. 1001-1034.

Weaver, E. A., Kenney, H. E., and Wall, M. E. 1960. Effect of concentration on the microbiological hydroxylation of progesterone. Applied Microbiology, 8, pp. 345-48.

Willaman, J. J., and Schubert, B. G. 1961. Alkaloid-bearing plants and their contained alkaloids. Technical Bulletin 1234. U. S. Department of Agriculture, Washington, D. C.

Woodbury, A. M., Wall, M. E., and Willaman, J. J. 1961. Steroidal sapogenins. LVIII. Steroidal sapogenins from the Joshua tree. Economic Botany 15, pp. 79-86.

Rothman, E. S., and Wall, M. E. February 14, 1961. Preparation of 11α-hydroxy progesterone. U. S. Patent 2,971,964.

Rothman, E. S., and Wall, M. E. August 29, 1961. Intermediates in the conversion of 11-ketodiosgenin to Cortisone. U. S. Patent 2,998,436.

Walens, H. A., and Wall, M. E., June 13, 1961. 11,12-Epoxy-pregnenolone derivatives and intermediates in the production thereof. U. S. Patent 2,988,548.

Walens, H. A., and Wall, M. E. December 5, 1961. 21-Acetoxy-11β, 12β-epoxy-5α-pregnon-3,20-dione and process. U. S. Patent 3,012, 027.

Weaver, E. A., and Kenney, H. E. June 20, 1961. Process for promoting microbial transformation reactions. U. S. Patent 2,989,439.

Analysis of spices and spice oils.

Datta, P. R., ed. 1960. Official analytical methods of the American Spice Trade Association, American Spice Trade Association, New York, N. Y. p. 45.

Datta, P. R. and Susi, H. 1961. Quantitative differentiation between natural capsaicin (8-methyl-N-vanillyl-6-nonenamide) and synthetic capsaicin (vanillyl-n-nonanamide). Anal. Chem. 33, p. 148.

General.

Krewson, Charles F. and Saggese, E. J. 1960. Chemistry of some amino acid derivatives of 2,2-dichloropropionic and 2,3,6-trichlorobenzoic acids. Weeds, 8, pp. 407-412.

Ogg, C. L. 1960. Report on microchemical methods. J. Assoc. Offic. Agr. Chemists, 43, pp. 682-683.

Ogg, C. L. 1960. Determination of nitrogen by the micro-Kjeldahl method. J. Assoc. Offic. Agr. Chemists 43, pp. 689-693.

Ogg, C. L. 1960. Microdetermination of molecular weight. J. Assoc. Offic. Agr. Chem. 43, pp. 693-694.

Ogg, C. L. 1961. Report on microchemical methods. J. Assoc. Offic. Agr. Chemists 44, p. 258.

Saggese, E. J. and Krewson, C. F. 1960. Bioactive compounds. Synthesis and physical properties of 2,4,5-trichlorophenoxyacetylated amino acids. Journal of Chemical and Engineering Data, 5, pp. 476-477.

Steyermark, A., Alber, H. K., Aluise, V. A., Huffman, E. W., Jolley, E. L., Kuck, J. A., Moran, J. J., Ogg, C. L. and Pietric, C. E. 1960. Report on recommended specifications for microchemical apparatus. Part III. Volumetric glassware. Micropipets. Anal. Chem. 32, pp. 1045-1046.

FLAXSEED INDUSTRIAL UTILIZATION OF LINSEED OIL
Northern Utilization Research and Development Div., ARS

Problem. Traditional markets for linseed oil, the major drying oil produced and used in the United States, are threatened by growing use of synthetic products derived from nonagricultural sources. Thus, over the years 1950-1960, use of linseed oil in linoleum and oilcloth decreased from 107 to 22 million pounds because of displacement by synthetic materials capable of better performance. During the same period, consumption of synthetic products in protective coatings increased by 50 percent. Solvent-thinned, exterior house paints, the largest remaining outlet for linseed oil, are being displaced to a significant and growing extent by recently developed water-thinned, synthetic resin emulsion paints that have many advantages such as ease of cleanup, fast drying, and freedom from objectionable odors. Consumption of these synthetic emulsion coatings is estimated at 10 to 20 percent of the 100 million gallons of exterior house paints produced in 1960.

To restore the competitive position of linseed oil, new or expanded markets are urgently needed. Chemical modification of linseed oil offers opportunities to obtain new products that can compete with nonagricultural synthetic products and thus stop, or even reverse, the present downward trend in utilization of linseed oil. For example, development of satisfactory emulsions and water-soluble vehicles that combine the attractive properties of synthetics with the inherent protective advantages of oil-based finishes could enable linseed oil to recover lost markets in protective coatings, which were produced to the extent of nearly 670 million gallons in 1960. Chemical modification also should open entirely new outlets for linseed oil such as the organic chemical industry which now produces 15 billion pounds of end products and is expected to reach 25 billion pounds by 1965. To furnish a sound basis for chemical modification, an adequate program of basic research on linseed oil is required to furnish new leads and new concepts that will point the way to those products having the best chance for acceptance in the market place.

USDA PROGRAM

The Department conducts a continuing long-range program involving analytical, organic and physical chemists and chemical engineers engaged in basic research on the chemical reactions of linseed oil and its component fatty acids and in the application of the knowledge gained to the development of new or improved products for the chemical and protective coating industries.

The Federal scientific effort concerned with research on industrial uses for linseed oil totals 17.8 professional man-years. Of this number 7.4 is devoted to industrial chemical products and 10.4 to protective coating products.

The current program at Peoria, Illinois, does not include research specifically devoted to chemical composition and physical properties. During the reporting period contract research on phospholipids of flax and on the substances formed during after-yellowing of linseed oil films was discontinued.

Research at Peoria, Illinois, on industrial chemical products (6.5 professional man-years) involves exploratory studies to find new reactions and chemical derivatives and basic and applied research on cyclic fatty acids. During the reporting period research other than engineering studies on conversion of linolenic acid to cyclic acids containing 18 carbon atoms was discontinued to permit more intensive investigation of a newly discovered type of cyclic acid containing 20 carbon atoms. Research contracts on industrial chemical products (.9 professional man-year) are in effect at the University of Arizona, Tucson, Arizona, for studies on polymerization of vinyl monomers derived from cyclic and other fatty acids (.3 professional man-year) and at Battelle Memorial Institute, Columbus, Ohio, for evaluation of aldehyde products derived from linseed oil (.6 professional man-year).

Studies on protective coating products in progress at Peoria, Illinois, (9.0 professional man-years) include investigations on new polymers from linseed oil for use as water-soluble vehicles for coatings and basic and applied research on problems related to development of linseed emulsion paints. During the reporting period research, except for provision of samples to interested industrial companies, was discontinued on linseed vinyl ethers and their use as protective coatings. Research contracts on protective coating products (1.4 professional man-years) are in effect with the University of Southern California, Los Angeles, California, for basic physical chemical studies on linseed oil emulsions and pigment suspensions (.7 professional man-year) and with Kansas State University, Manhattan, Kansas, for research on the use of linseed oil to protect concrete (.7 professional man-year). During the reporting period contract research on evaluation of linseed vinyl ether coatings and on special linseed oil copolymers for emulsion paints was completed.

The Department also sponsors research (10.1 professional man-years) conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition and physical properties (3.0 professional man-years) involves a grant to the Experiment Station for Fats and Oils, Milan, Italy, for studies on minor constituents of linseed oil. Research on industrial chemical products (3.0 professional man-years) is also conducted by this institution under a grant for the

investigation of products obtained by thermal polymerization of linseed and other polyunsaturated vegetable oils. Research on protective coating products involves a grant to the Paint Research Station, Teddington, England, for fundamental research on organometallic compounds as components of protective coatings (4.1 professional man-years).

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported no work on industrial utilization of linseed oil.

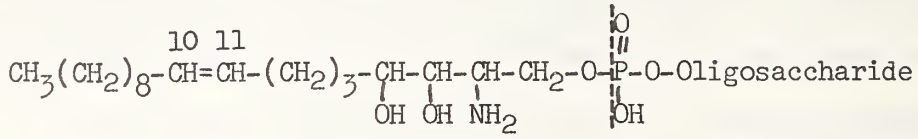
Industry and other organizations conduct interesting and significant research on linseed oil. Chemical research to develop new or improved products from linseed oil is conducted almost exclusively by the largest processors of flaxseed and by several of the largest manufacturers of protective coatings. A major share of the research of most of these companies concerns development of new protective coating products from linseed oil. In some organizations, research effort is devoted to development of other types of industrial products and to improvements in processing to achieve economies in recovering linseed oil from flaxseed or to obtain higher grades of oil. Very little basic research is done. Manufacturers of protective coatings, as well as many other industrial companies, endeavor to improve products based on existing materials available from linseed oil in order to meet competitive situations or to solve other problems incidental to company operations. Except for certain of the largest protective coatings companies, this activity, although large, does not appear to involve research to derive or develop new or improved products from linseed oil itself. Member companies of the National Flaxseed Processors Association support a fellowship at the Northern Division, Peoria, Illinois, for research on emulsion paints. Frequently, the companies participate in formal or informal cooperation with the Division for testing and evaluation of experimental products developed at the Division. With the exception of the cooperative work, the nature of the processes and products studied and the results of the research are kept confidential by the companies. Estimated annual expenditures are equivalent to approximately 2.0 professional man-years in basic research, 5.0 professional man-years in development of industrial products other than protective coatings, 5.0 professional man-years in improvement of processing technology, and 35 professional man-years in development of protective coatings products.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Flaxseed phospholipides. Final studies at the University of Illinois on characterization of flaxseed phospholipides have revealed

additional details of the composition of the oligosaccharide components of flax phytoglycolipides:



Phytosphingosine moiety

Unlike corn, soybean, and peanut phytoglycolipides, flax phytoglycolipide is a mixture. Upon hydrolysis two oligosaccharides were obtained:

(a) -Inositol - glucuronido - glucosamine { galactose, mannose, arabinose }

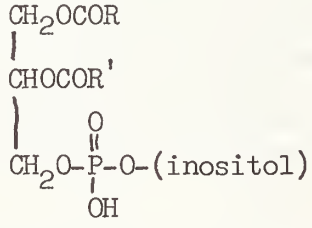
This oligosaccharide moiety was also found in soybean phytoglycolipide.

(b) Oligosaccharide with molecular weight greater than 2,000, yielding on hydrolysis inositol, galactose, arabinose, and fucose. Fucose was not found in soybeans or corn and may be unique for flax.

Thus it appears that a variety of phytoglycolipides may exist in seed phosphatides, consisting of a series of related molecules with different oligosaccharides.

In flax, the phytosphingosine moiety has a <u>trans</u> double bond at position 10,11. The soybean product has this double bond at the 11,12 position, while in corn the phytosphingosine base is saturated.

Linseed phosphatidyl inositide has the following structure:



R and R' are fatty acid moieties. Major components are palmitic and oleic acids, with minor amounts of stearic, heptadecanoic and higher unsaturated fatty acids. This inositide was readily prepared in pound lots. Samples were distributed to interested outside investigators for study of possible applications in medicine, enzymology and microbiology. At the Northern Division, the substance was found to

improve flavor and oxidative stability of edible soybean oil in concentrations as low as 0.01 percent.

2. After-yellowing of linseed oil films. It was reported in 1960 that the sequence of reactions leading to formation of yellow substances in linseed oil films could be blocked by aldehydes containing α-methylene groups. To prevent or decrease after-yellowing of films under practical conditions, aldehydes were needed that would have the required structure and that would be nonvolatile and adequately soluble in the oil. Two types of aldehydes were found that met these criteria:

1. Glycol aldehyde esters, $\begin{matrix} CHO \\ | \\ CH_2OCOR \end{matrix}$

2. Monoglyceryl esters of hemialdehydic acids, $\begin{matrix} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OCO(CH_2)_nCHO \end{matrix}$

The following table shows some of the results obtained with azelaaldehydic acid monoglyceride (AM) (type 1) and glycolaldehyde palmitate (GAP) (type 2).

	Onset of yellowing[a] (hrs.) with stated inhibitor			
Oil	None	0.5% AM	0.5% GAP	10% GAP
Menhaden	33	112	--	--
Linseed methyl esters	70	122	70	168
Safflower methyl esters	140	159	--	--

a/ Accelerated tests.

Compounds of type 1 appear to be more effective than those of type 2. This research, which was conducted by the Hormel Institute, University of Minnesota, Austin, Minnesota, has been completed.

3. Minor constituents of linseed oil. Analysis of unsaponifiables of linseed oil has revealed the presence of at least 43 paraffin hydrocarbons (normal and branched), terpene and other alcohols, waxes, sterols, esters, and squalenes. This work is being done at the Experiment Station for Fats and Oils, Milan, Italy.

B. Industrial Chemical Products

1. Cyclic acids. Cyclization: Conditions and catalysts for alkaline cyclization of linolenic acid of linseed oil were studied intensively.

Significant improvements in this cyclization process, which yields cyclic acids containing 18 carbon atoms (C-18), were achieved. t-Butoxide catalyst in t-butyl alcohol converted 83 percent of the linolenic acid present in linseed fatty acids to C-18 cyclic materials. When cyclization was conducted in ethylene glycol with the sodium salt of ethylene glycol as the catalyst, yields were equivalent to the best previously found. With sodium hydroxide as catalyst and ethylene glycol as solvent, a yield of 46 grams of cyclic acid per 100 grams of linseed oil was obtained when the reaction was conducted at 295° C. under ethylene. This yield is 92 percent of theoretical based on linolenic acid. Pilot-plant runs indicate up to 98-percent yields based on linolenic acid with ethylene present. Cyclization has also been successfully performed as a continuous process in a specially designed reactor. Yields of cyclic acid were somewhat lower than those from batch operation, but formation of undesired polymers was substantially reduced. Continuous processing with ethylene present gave yields about equal to those from batch runs without ethylene. The increased yield of cyclic acid in the presence of ethylene was found to result from addition of ethylene to the conjugated fatty acids formed under the alkaline conditions of the reaction. By reaction at 260° of ethylene with a preformed conjugated acid, 9,11-trans,trans-octadecadienoic acid, an adduct was obtained in 92-percent yield (no catalyst required). This adduct is a new cyclic acid product containing 20 carbon atoms (C-20). At 3,000 p.s.i. alkaline cyclization of soybean oil and safflower oils in the presence of ethylene gave yields of C-20 cyclic acids amounting to 40 g./100 g. oil and 57 g./100 g. oil, respectively.

Derivatives: Accelerated yellowing tests showed that oil-modified alkyd resins modified with cyclic acids yellowed less than alkyds modified with soybean or safflower oils. Other evaluation tests showed that modification of alkyd resins with cyclic acids improved drying times, hardness, and resistance to water and alkali over resins modified with natural vegetable fatty acids and oils.

The amides prepared from cyclized linseed fatty acids (unpurified except for removal of polymers) (I) and from hydrogenated cyclic acids (II) have low melting points (33° and 43°, respectively) and high solubilities in carbon tetrachloride and benzene compared to hydrogenated tallow amides. The amide of II exhibited better compatibility with synthetic resins than did oleamide. The nitriles of I and II are liquids having low freezing points (-21° and -25°, respectively). The nitriles of II were compatible with vinyl chloride-acetate copolymer (PVCA). Sheets of PVCA plasticized with nitrile were soft and flexible, but more extensive evaluation in this application appears desirable. The ethenoxylated amide and quaternary amine derived from I have surface-active properties comparable to similar fat-derived substances. The diethanolamides of I and II have very low oil-water interfacial tensions and were very nearly equivalent to

coconut diethanolamides in surface-active properties. Laboratory studies on production of C-18 cyclic acids by the alkali-catalyzed reaction in the absence of ethylene have been completed. Engineering and pilot-plant investigations are continuing. Information and samples of C-18 cyclic acids have been made available to interested industrial companies.

2. Polymerization of vinyl compounds. Studies were initiated at the University of Arizona on the use of vinyl esters of hydrogenated cyclic acid, vinyl 9,10-dichlorostearate, vinyl 9,10,12,13-tetrachlorostearate and other fatty vinyl esters as internal plasticizers for polyvinyl chloride. Polyvinyl chloro derivatives have been obtained that have lower melting and brittle temperatures than had previously been obtained with fatty products.

3. Glyceride polymers. Characterization of glycerides obtained at various stages of thermal polymerization of soybean and linseed oils is being investigated at the Experiment Station for the Fats and Oils Industry, Milan, Italy. During the past year a bibliography of 227 pertinent references was assembled. Forty polymerizations of linseed oil were conducted at various temperatures and for various lengths of time. A portion of each sample was chromatographed on columns charged with ashless cellulose powder. Materials elutable with methanol were converted to methyl esters and examined by gas chromatography. Also, ultraviolet and infrared spectra were obtained on the eluted oils. Since the chromatographic procedure separates materials that appear to be unpolymerized, it is noteworthy that this methanol-elutable material was, in every instance, formed in about 20-percent yields. Definite conclusions have not yet been reached regarding the significance of this observation or of the other data so far collected.

C. Protective Coating Products

1. Vinyl ether coatings. Contract research at Battelle Memorial Institute covering end-use evaluation of selected conjugated linseed vinyl ether polymers showed that although very significant improvement in film properties had been achieved during the course of the work, even the best polymers had one or more deficiencies. Improved curing properties, better resistance to forming operations (as in making can ends from coated sheet metal), and increased compatibility with other commercially available resins would be desirable.

A short time before conclusion of the contract work, methods for styrenating vinyl ether polymers were discovered. Only a few tests on these could be run at Battelle, but the results were encouraging because they showed that the styrenated polymers had improved properties, including compatibility with certain commercial resins. However, these styrenated polymers were stable only for short periods, eventually gelling. A technique was developed that permits essentially

complete incorporation of up to 70 percent of styrene into low-molecular-weight (1,500) conjugated linseed vinyl ether polymers. Comparable results were obtained with various conjugated linseed vinyl ether copolymers, including those made with cyclic comonomers. Basis of the technique is use of dipentene either as the only or as the predominant reactive solvent for styrenation. It was further demonstrated that a vinyl ether polymer could be prepared and styrenated without isolation of the intermediate polymer. Further evaluation of both styrenated and unstyrenated vinyl ether copolymers gave results indicating that research on fatty vinyl ether polymers has very nearly achieved a material that would be definitely interesting to industry. A major problem is to attain adequate resistance to the forming operation. Experience with the recently tested samples suggests that some combination of the following monomers might succeed: conjugated linseed and soybean vinyl ethers, isobutyl vinyl ether, cyclopentadiene, and styrene. Research on vinyl ether coatings has been discontinued except for preparation of samples for detailed evaluation by two cooperating commercial organizations.

2. Emulsion paints. Research on linseed emulsion paints for exterior use on wood was undertaken in 1959 in cooperation with the National Flaxseed Processors Association as a means of retaining the market for linseed oil in competition with synthetic emulsion house paints. The results of this program have been eminently successful. During the past year, two companies began marketing emulsions from which stable paints containing zinc oxide (for mildew resistance) can be formulated. Another company is planning to market a linseed oil emulsion. Current reports are that some 50 paint manufacturers are marketing exterior house paints prepared with these emulsions as vehicles. Companies marketing these emulsions have publicly acknowledged the importance of the Department's research to the success of this development. Several of the more significant results of the Department's research were described in the report for 1960. These included development of paints that dried to touch in 15-30 minutes and could then be recoated; use of chelating agents to minimize destabilization of paints by metallic driers; use of hydroxyethyl cellulose to improve surface-dry and water resistance; and development of new, reactive emulsifiers derived from linseed oil.

During the present reporting period, further important contributions were made including development of stable paints containing reactive zinc oxide pigment; information on variables affecting brushing, leveling, wet-edge and other application properties; demonstration of previously unreported interactions between titanium oxide and zinc oxide in aqueous slurries that lead to unstable viscosity and pH; and discovery of several means for preventing such interactions, e.g., proper addition of ethylene glycol, correct concentration of organic dispersing agent or use of phosphate dispersing agents (tests uncompleted). Despite the success so far achieved, further improvements in linseed

emulsion paints are needed to meet present and future competition from synthetics. Problems relating to application characteristics, storage stability, and performance over bare wood, especially redwood and red cedar, remain to be solved.

A reproducible ultracentrifugal method was developed at the University of Southern California for quantitative measurement of stability of oil emulsions. The method has been further refined and its use in evaluating an important variable affecting emulsion stability has been demonstrated. Thus it was shown that stability of a Nujol-water emulsion stabilized with sodium dodecyl sulfate (SDS) increases with SDS concentration until the critical micelle concentration is reached after which stability was independent of concentration. Results obtained from experiments on centrifugation of emulsions suggest that interdroplet water may be squeezed out from between the oil droplets during centrifugation without coalescence necessarily ensuing and that this water may then gradually diffuse back on standing. Studies on the interaction of zinc oxide and surfactants showed that when alkali was added to a solution containing zinc chloride and SDS, a precipitate was obtained at a pH lower than that at which zinc hydroxide precipitates under similar conditions but in the absence of SDS. X-ray diffraction patterns revealed that the precipitate was not zinc hydroxide but might be a basic zinc dodecyl sulfate of variable composition. When Tamol 731 (a dispersing agent) was substituted for SDS, no precipitation occurred even at pH 10, indicating that zinc ions are bound by Tamol. A number of different Nujol emulsions containing zinc oxide were prepared. X-ray diffraction showed that the suspended species is zinc oxide and not zinc hydroxide. With acid sols, where the zinc oxide carries a positive charge, no emulsions could be stabilized and pigment became oil-wet. With an alkaline sol (pH 12) stability of dilute oil-water emulsions increased as the amount of zinc oxide was increased. Demonstration of interactions between zinc oxide and surfactants has important implications in relation to stability of emulsion paints containing zinc oxide. Thus, such interactions might result in reduction of amounts of emulsifiers and dispersing agents needed for stability to ineffective levels or in conversion of zinc oxide into some other chemical entity having different requirements for dispersion and stabilization.

At Stanford Research Institute, acrylate groups have been successfully introduced into bodied linseed oil (M-37 oil). This result was accomplished by two methods: (1) methanolysis followed by reaction with acrylyl chloride, or (2) glycerolysis with sodium glyceroxide followed by reaction with acrylyl chloride. A method for grafting methyl acrylate onto M-37 linseed oil also was developed; the product is soluble but rapidly crosslinks in air to an insoluble product. The graft copolymer was made into an emulsion paint but the oil gelled too readily for best results and films remained tacky for extended periods. This research has been completed.

3. Organometallic compounds in paints. At the Paint Research Station, Teddington, England, products having good drying properties (set-to-touch in one-half hour; no drier) have been obtained by reacting oleyl-linoleyl (or linoleyl-linolenyl) acetoacetate with aluminum isopropoxide and then linseed fatty acids. Other types of compounds under investigation include reaction products of titanium isopropoxide, triisopropyl borate and aluminum isopropoxide, with ethanolamides of oleic and linoleic acids, with fatty anilides, and with fatty-substituted amino alcohols.

PUBLICATIONS AND PATENTS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Chemical Composition and Physical Properties

Capella, P. (Experiment Station for the Fats and Oils Industry, Milan, Italy). 1961. Cyclo-arthenol: a minor constituent of linseed oil. Nature 190(4771), pp. 167-168.*

Carter, H. E., Galanos, D. S., Hendrickson, H. S., Jann, B., Nakayama, T., Nakazawa, Y., and Nichols, B. (University of Illinois, Urbana). 1962. Biochemistry of the sphingolipids. XIV. Inositol lipids of flaxseed. J. Am. Oil Chemists' Soc. 39(2), pp. 107-115.

Privett, O. S., Blank, M. L., Covell, J. B., and Lundberg, W. O. (University of Minnesota, St. Paul). 1961. Yellowing of oil films. J. Am. Oil Chemists' Soc. 38(1), pp. 22-27.

Privett, O. S., Blank, M. L., and Lundberg, W. O. (University of Minnesota, St. Paul). 1961. An accelerated test of the yellowing tendency of drying oils. J. Am. Oil Chemists' Soc. 38(1), pp. 27-30.

Industrial Chemical Products

Beal, R. E. Oct. 24, 1961. Method of preparing monomeric cyclic unsaturated acids. U. S. Patent 3,005,840.

Beal, R. E., Sohns, V. E., Eisenhauer, R. A., and Griffin, E. L., Jr. 1961. Production of linolenic acid from linseed oil. J. Am. Oil Chemists' Soc. 38(10), pp. 524-527.

Dunphy, J. F., and Marvel, C. S. (University of Illinois, Urbana). 1960. Vinyl octadecyl ether copolymers. J. Polymer Sci. 46(148), pp. 542-543.

Dunphy, J. F., and Marvel, C. S. (University of Illinois, Urbana). 1960. Reactivity ratios of vinyl 2-chloroethyl ether in cationic copolymerization with vinyl, alkyl ethers and para-substituted α-methylstyrenes. J. Polymer Sci. 47(149), pp. 1-8.

Friedrich, J. P. 1961. Low-temperature crystallization apparatus for semimicro quantitative work. Anal. Chem. 33(7), pp. 974-975.

*Research supported by PL 480 funds.

Friedrich, J. P., Teeter, H. M., Cowan, J. C., and McManis, G. E. 1961. Liquid C-18 saturated acids derived from linseed oil. J. Am. Oil Chemists' Soc. 38(7), pp. 329-332.

Hill, J. C.,[1] Marvel, C. S.,[1] Friedrich, J. P., and Cowan, J. C. ([1]University of Arizona, Tucson). 1962. Preparation and polymerization of vinyl esters of cyclic fatty acids. Preprint booklet, Organic Coatings and Plastics Chemistry 22(1), p. 35.

Marvel, C. S., and Dunphy, J. F. (University of Illinois, Urbana). 1960. Cationic copolymerization of some alpha-methylstyrenes with vinyl 2-chloroethyl ether. Solvent effects. J. Org. Chem. 25(12), pp. 2209-2211.

Marvel, C. S., and Rogers, J. R. (University of Illinois, Urbana). 1961. The preparation and polymerization of some long-chain mono-, di- and triolefins with metal coordination catalysts. J. Polymer Sci. 59(152), pp. 335-351.

Miller, W. R., Teeter, H. M., Schwab, A. W., and Cowan, J. C. 1962. Alkyd resins modified with cyclic fatty acids. A preliminary evaluation. J. Am. Oil Chemists' Soc. 39(3), pp. 173-176.

Scholfield, C. R., Cowan, J. C., and Friedrich, J. P. June 26, 1962. Linolenate-derived cyclic monomer fraction. U. S. Patent 3,041,360.

Protective Coating Products

Brekke, O. L., and Kirk, L. D. 1960. Nonconjugated linseed vinyl ether by vinyl transetherification. Preparation procedure. J. Am. Oil Chemists' Soc. 37(11), pp. 568-570.

Cowan, J. C. 1961. Linseed oil emulsion paints: Progress during 1960-61 at the Northern Regional Research Laboratory. Proc. 31st Flax Inst. U. S., Minneapolis, Minn., pp. 33-35.

Cowan, J. C. 1962. After dry, what? A general survey. Off. Dig., Fed. Soc. Paint Technology 34(449), pp. 561-574.

DeJarlais, W. J., and Teeter, H. M. 1960. Reactions of unsaturated fatty alcohols. X. Preparation of some copolymers of nonconjugated linseed vinyl ether. J. Am. Oil Chemists' Soc. 37(11), pp. 556-558.

DeJarlais, W. J., O'Donnell, J. L., and Teeter, H. M. 1961. Preparation of some ethyl higher-alkyl acetals and their conversion to vinyl ethers. J. Am. Oil Chemists' Soc. 38(5), pp. 241-243.

Dufek, E. J., Gast, L. E., and Teeter, H. M. 1962. Reactions of unsaturated fatty alcohols. XIII. Copolymers of unsaturated fatty vinyl ethers and cyclic monomers. J. Am. Oil Chemists' Soc. 39(5), pp. 238-241.

Gast, L. E., Stenberg, R. J., Schneider, W. J., Teeter, H. M., Schoen, H. O.,[1] Brand, B. G.,[1] and Mueller, E. R.[1] ([1]Battelle Memorial Institute, Columbus, Ohio). 1960. Reactions of unsaturated fatty alcohols. XII. Polymers from polyunsaturated fatty vinyl ethers and certain crosslinking monomers. Off. Dig., Fed. Soc. Paint Technology 32(427), pp. 1091-1101.

Mayo, F. R., and Gould, C. (Stanford Research Institute, Menlo Park, California). 1962. Copolymerization of methyl esters of C_{18} acids. Preprint Booklet, Organic Coatings and Plastics Chemistry Division, American Chemical Society 22(1), p. 42.

Mustakas, G. C., and Griffin, E. L., Jr. Jan. 3, 1961. Copolymerization method. U. S. Patent 2,967,166.

Princen, L. H., and DeVena, M. J. 1962. The interaction between the zinc oxide and titanium dioxide in water. J. Am. Oil Chemists' Soc. 39(5), pp. 269-272.

Schneider, W. J., Gast, L. E., Schwab, A. W., and Teeter, H. M. 1962. Reactions of unsaturated fatty alcohols. XIV. Preparation and properties of styrenated fatty vinyl ether polymers. J. Am. Oil Chemists' Soc. 39(5), pp. 241-244.

Schwab, A. W., Kubie, W. L., Stolp, J. A., Cowan, J. C., and Teeter, H. M. 1961. Surface drying of linseed oil emulsion paints. Off. Dig., Fed. Soc. Paint Technol. 33(437), pp. 747-758.

Teeter, H. M., Dorman, L. C., and Harris, L. 1960. Reactions of polyunsaturated fatty alcohols. IX. Molecular-weight distribution of some conjugated soybean vinyl ether homopolymers. J. Am. Oil Chemists' Soc. 37(11), pp. 552-555.

SOYBEAN FOOD AND INDUSTRIAL USES FOR SOYBEAN OIL
Northern Utilization Research and Development Div., ARS

Problem. Soybean oil is now the major edible oil of the United States and the most important source of nutritionally important linoleic acid. However, this oil contains an unstable component (linolenic acid) that limits its use as a liquid oil both domestically and in foreign markets. It is estimated that in 1961 over 3.2 billion pounds of soybean oil (about 90 percent of total domestic use) was consumed in edible products, of which somewhat more than two-thirds was consumed in hydrogenated form as margarine and shortening. However, production of soybeans continues to increase rapidly and is expected to be about 700 million bushels in 1962.

The most promising outlets for oil from this ever-growing production of soybeans appear to be in foreign markets as edible oils and fats and in domestic industrial uses. The potential market for vegetable oils imported by Europe is estimated at 7.5 billion pounds by 1975. For soybean oil to capture a growing share of this market, more information is needed to show how to eliminate unstable linolenic acid without loss of nutritive value, to determine the extent to which minor constituents influence flavor and other properties of the oil, and to discover methods for modifying hydrogenated soybean oil to achieve desired functional properties such as melting point and texture. This information would also serve as the basis for improving soybean oil for domestic use both as a liquid oil and in its hydrogenated forms. Some additional consumption in the United States might be anticipated because of extended utility resulting from these improvements, even though consumption of edible fats and oils mainly increases with population growth. To achieve the objective, a broad program of basic and applied research is required to provide more knowledge of the properties of linolenic acid and of minor constituents of soybean oil; of the changes that take place in these and other components during oxidation, hydrogenation, and heating; of the effects of these changes on flavor, nutritive value, stability, and other qualities of the oil; and of the effects of modification of glyceride structure on functional properties of hydrogenated forms of soybean oil.

As an industrial oil, soybean, like linseed oil, is faced with growing competition from synthetic products derived from nonagricultural sources. As an industrial source of linoleic acid, soybean fatty acids must also compete with tall oil fatty acids, a byproduct of paper manufacture. The best opportunity for increasing industrial applications of soybean oil appears, therefore, to be development of products that retain the glyceride structure of the oil. Thus, aldehyde oils, a recent discovery of Department scientists, appear to have a promising future, if current research and development is successful, in the

3-billion-pound market for resins, fibers, coatings, plastics, plasticizers, pesticides, and paper and textile chemicals. To achieve the potential industrial value of aldehyde oils and other soybean glyceride products, more fundamental information is needed on reactions of soybean oil that will preserve the glyceride structure and on the physical and chemical properties of the products. Upon this basis, development of a wide variety of new, industrially useful products should be possible.

USDA PROGRAM

The Department has a continuing long-range program involving analytical, organic and physical chemists and chemical engineers engaged in basic and applied research on edible and industrial uses of soybean oil. A food technologist is also required by the program in connection with organoleptic evaluation of edible oils. Objectives of research on edible soybean oil are to identify undesirable flavor components of the oil, to develop basic information on the chemical changes and mechanisms involved in formation or suppression of these components and to apply the knowledge gained to the development of edible soybean oil having improved oxidative, thermal and organoleptic stability. Objectives of research on industrial utilization are to obtain new information on reactions of soybean oil and its components and to use this information to develop new or improved products for use by the chemical and other industries.

The Federal scientific effort for research on soybean oil totals 23.3 professional man-years. Of this number 6.0 are devoted to chemical composition and physical properties, 10.2 to edible utilization, and 7.1 to industrial utilization.

Research at Peoria, Illinois, on chemical composition and physical properties (6.0 professional man-years) is concerned with isolation and identification of components affecting flavor stability of soybean oil and with basic studies on autoxidation of this oil.

Research at Peoria, Illinois, on edible utilization of soybean oil (9.0 professional man-years) involves basic and applied studies on selective hydrogenation as a means of stabilizing soybean oil by removal of linolenate. During the reporting period research on use of phosphonic acids to stabilize soybean oil was discontinued. A research contract (1.2 professional man-years) is in effect with Armour Research Foundation, Chicago, Illinois, for preparation and evaluation of catalysts for selective hydrogenation.

Research at Peoria, Illinois, on industrial utilization of soybean oil (6.5 professional man-years) involves exploratory studies to find new reactions and products and basic and applied investigations of aldehyde oils and other aldehydic products. During the reporting

period research on Diels-Alder adducts from conjugated soybean fatty acids was discontinued. Exploratory studies on oxidative cleavage of unsaturated fatty acids of soybean oil were completed, and development work is being undertaken. A research contract (.6 professional man-year) is in effect with Battelle Memorial Institute, Columbus, Ohio, for preliminary evaluation of aldehyde oils and other aldehydic products from soybean oil in selected applications.

The Department also sponsors research on soybean oil (18.0 professional man-years) conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition and physical properties (4.7 professional man-years) involves grants to the Institute for Fats and Their Derivatives, Seville, Spain, for research on removal of trace metals from soybean oil with ion-exchange resins (2.0 professional man-years) and to Gdansk Polytechnic, Gdansk, Poland, for studies on soybean sterols and their effect on stability of the oil (2.7 professional man-years). Research on edible utilization (6.0 professional man-years) is conducted under grants to the University of Granada, Spain, for studies on the effect of processing on frying quality of soybean oil (3.8 professional man-years) and to Tokyo University, Japan, for research on hydrogenation of soybean oil (2.2 professional man-years). Research on industrial utilization (7.3 professional man-years) involves grants to the University of Helsinki, Finland, for studies on separation of pure fatty acids from mixtures such as soybean fatty acids (2.3 professional man-years); Queen Mary College, University of London, England, for basic studies on alkaline cleavage of polyunsaturated fatty acids (2.0 professional man-years); and the Experiment Station for the Fats and Oils Industry, Milan, Italy, for research on oxidation with atmospheric oxygen to obtain new soybean oil derivatives (3.0 professional man-years).

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of .6 professional man-year, divided between subheadings as follows: chemical composition and physical properties, .5; industrial utilization, .1. A limited amount of effort is devoted to problems of the chemical composition and physical properties of soybean oil. Thermal polymerization, heat damage, and flavor reversion are special problems under study. Industrial utilization of soybean oil is the subject of an exploratory study at one location. This work involves testing new use ideas and determining their feasibility.

Industry and other organizations conduct a substantial research program on soybean oil. The predominant interest appears to be improvement of soybean oil for use in various edible products such as shortening, margarine, and salad and cooking oils. A considerably smaller, but still important, emphasis is placed on industrial utilization of soybean oil. Basic research on edible and industrial utilization of soybean oil

receives a moderate share of the effort. The research on industrial utilization is predominantly concerned with finding new industrial outlets rather than improvement of end-products containing soybean oil. In the edible field, however, research is directed both towards modification of end-products to meet competitive situations and towards basic improvements in processing the oil to make it more suitable for use in edible products. The companies have cooperated extensively in evaluation of edible and industrial products from soybean oil, and of processes for making them, developed by the Department. During 1961-62 the National Soybean Processors' Association is supporting basic research (about .3 professional man-year) at the Northern Division on flavor components of reverted soybean oil. This work was supported in 1960-61 by the Soybean Council of America. Except for cooperative research, the exact nature of the products and processes investigated by industry and the results of the research are kept confidential or patented by the companies. Estimated annual expenditures for research on soybean oil are equivalent to approximately 25.0 professional man-years in basic research, 110.0 professional man-years in applied, developmental, and product improvement research on edible products from soybean oil, and 40.0 professional man-years in applied and developmental research on new industrial products.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Flavor components. Studies showed that unsaponifiables by all methods of preparation were detrimental to cottonseed oil when added at levels equal to those present in soybean oil. (Cottonseed oil was used for these tests to avoid complications from inherent instability of soybean oil.) Indeed, some samples were detrimental to cottonseed oil at levels of one-half to one-third the amount present in soybean oil, and flavor scores typical of soybean oil were obtained.

Chromatography using methanol and methanol-benzene separated the unsaponifiables into three fractions of widely different polarity. Gas chromatography showed the fractions to contain 11, 4, and 5 components, respectively. Fraction I comprised 6 to 50 percent of the unsaponifiables and contained hydrocarbons and tocopherols; Fraction II comprised 18 to 60 percent, was heat sensitive, and was modified by ester saponification; and Fraction III comprised 20 to 40 percent and contained steroids. Autoxidation of the oil increased the nonpolar, hydrocarbon components of the unsaponifiables. Nonpolar components (I) were more detrimental to oxidative stability than more polar components (III). Purified stigmasterol and sitosterol were not detrimental to flavor or oxidative stability of cottonseed oil.

The presence of the following classes of organic compounds in flavor and odor components removed from refined soybean oil (obtained from beans by extraction) by high-vacuum stripping was observed: saturated and unsaturated hydrocarbons (methane, ethylene and higher homologs), alcohols, methyl and ethyl esters (up to C_8 in volatile fractions), aldehydes, acetals, methyl ketones and ethers.

2. Autoxidation. The centers where oxygen first attacks linolenic acid have been located by a combination of reductive and dehydration steps carried out on purified methyl linolenate hydroperoxide. The results showed that the terminal α-carbons of the polyene system have the highest reactivity towards oxygen. Knowledge of the preferential sites of oxidation is useful information in predicting the type and structure of compounds obtained on the decomposition of these hydroperoxides.

3. Removal of prooxidant metals. Studies on the use of ion-exchange resins to remove trace prooxidant metals from soybean oil are in progress under a PL 480 grant to the Institute of Fats and Their Derivatives, Seville, Spain. By means of statistically designed experimentation the effects of pertinent variables in removal of prooxidant metals with ion-exchange resins were evaluated. So far, the most favorable conditions appear to be treatment at 20° C. of 50 g. of soybean oil, diluted 1:1 with acetone, with 30 ml. of Amberlite CG-120, type I resin. By this procedure the following results were obtained:

	Metal content, p.p.m.[a/]			
	Fe	Mn	Cu	Zn
Original oil	1.19	0.255	0.085	1.23
"Demetallized" oil	0.23	0.000	0.017	0.00

a/ Determined by spectrographic analysis.

4. Effects of sterols on flavor stability. Initial experiments conducted at Gdansk Polytechnic, Gdansk, Poland, showed that autoxidation of soybean oil resulted in formation of oxidized sterol components.

B. Edible Utilization

1. Selective hydrogenation. Countercurrent distribution (CCD) was used after large-scale fractional crystallization to isolate and identify isomers formed in catalytic reduction of methyl linolenate. Selective combination of fractions from CCD yielded samples containing 95 percent cis,cis dienes, 90 percent mixed cis,trans and trans,cis dienes, 95 percent cis monoene, and 90 percent trans monoene. Analysis

of the diene fractions indicate that (1) the major cis,cis dienes have their bonds in the same positions as the original methyl linolenate, i.e., 9,12; 9,15; and 12,15; (2) bond migration took place during formation of the cis,trans and trans,trans dienes and of a small fraction of the cis,cis dienes.

CCD with a hydrocarbon-acetonitrile solvent (650 transfer stages) resolves a hydrogenation mixture on the basis of amounts of unsaturation present. This system, however, does not separate the isomeric monoenes and dienes. Gas chromatography (GLC) on a 200-foot capillary column packed with Apiezon L does fractionate the isomeric components after prior separation into monoene and diene classes. These two forms of differential migration (CCD and GLC) were applied to the products of catalytic hydrogenation of methyl and glyceryl linolenate to learn if steric effects influence the complexities of the reaction and its products. Great complexity was effectively demonstrated, but little difference was found except for a relatively faster reaction rate for monoester. Kinetic evidence for a "triene-to-monoene shunt" in catalytic hydrogenation has been obtained with the use of radioactive tracers. Preferential attack of the trienoic ester as compared to the dienoate ester was also shown. Chemical reduction of linolenate with hydrazine was studied with radioactive tracers, but no evidence for the anomalous shunt behavior was obtained. The reaction rates for the chemical reduction of triene, diene, and monoene appear to be in approximately the same ratio as the number of double bonds present.

Another difficult problem is separation of mixtures of geometric isomers of C_{18} fatty acids. Separation of cis,cis, cis,trans, and trans,trans isomers has now been achieved by preparing the silver π-complex followed by countercurrent distribution. Partially hydrogenated methyl linolenate separated by this method showed that cis monoenes largely retained the double bond at the original 9, 12, and 15 positions; and the trans monoenes contained widely distributed double bonds between the C_7 and C_{16} positions, demonstrating migration along with isomerization. This argentation technique was applied to a shortening and a hydrogenated winterized oil, both commercially prepared from soybean oil. The results showed that there was 24.6 percent of oleic acid and 27-28 percent of linoleic acid (cis,cis diene) in the winterized oil as compared to 17.2 percent and 9 percent, respectively, in the shortening. Trans content of the shortening was more than twice that of the winterized oil.

A new "iron reversion test" may simplify evaluation of partially hydrogenated or fractionated soybean oils for stability as salad and cooking oils. Soybean oil showed a rapid, large drop in the flavor score when 0.3 p.p.m. of iron was added, whereas cottonseed oil showed only a small drop. In contrast, soybean oil partially hydrogenated to less than 3 percent linolenate showed a flavor score equivalent to cottonseed oil by this test. Exposure to a controlled light source for

several hours also gave a large drop in flavor score for soybean oil but much less of a drop for cottonseed or hydrogenated, winterized soybean oil.

Commercial hydrogenation catalysts have been surveyed for selectivity and isomerization. Selectivity was determined by the "crossover point procedure" on a linoleate-linolenate equimixture under standardized conditions. Ratios of reaction rate constants for nickel catalysts at 140° C. ranged between 1.48 and 2.71; for palladium catalysts at 25° C., 1.68 to 2.50; and for platinum catalysts at 25° C., 1.33 to 1.61. Trans contents for these three metal catalysts ranged from 18.0 to 22.8 percent, 16.7 to 25.3 percent, and 7.5 to 8.4 percent, respectively. A study of the variables affecting selectivity of a single nickel catalyst showed that trans content varied from 45.9 percent at 230° C. to 14.95 percent at 70° C. with linolenic acid. No selectivity for the 15-16 double bond in linolenate was found. No commercial hydrogenation catalyst was found that gave the high selectivity required without formation of trans isomers. Whereas platinum produced the lowest trans isomers, selectivities were also low. Sulfur-poisoned nickel gave highest selectivity but also highest trans content. The demonstration of such variability gives hope that a catalyst or conditions of hydrogenation can be found which will give desired high selectivity and low trans.

Contract research at Armour Research Foundation showed that no truly selective catalyst is available for hydrogenation of the linolenic acid component of soybeans without producing appreciable amounts of saturated products or trans isomers. Catalysts included special products imported from Japan that were claimed to have desired selectivity but did not. Selective catalysts for linolenate reduction also produced high trans isomers. The more active catalysts had greater selectivity. Differences in formation of trans isomers and in activity were found, suggesting that the preparation of new catalysts might be a fruitful area to explore.

C. Industrial Utilization

1. Oxidative cleavage of soybean oil and its fatty acids. An important advance was the discovery that partial ozonization of soybean oil can be successfully accomplished. By partial ozonization, aldehyde oils that have controlled content of carbonyl groups, and therefore, controlled reactivity towards other chemicals can be readily prepared. It was also possible to prepare partially ozonized oils retaining various amounts of the original olefinic unsaturation, thus adding possibilities of thermal or oxidative polymerization to reactions characteristic of the carbonyl groups.

Since cost of ozone is the most significant factor in determining the cost of an aldehyde oil, partial ozonization enables important savings to be made. The following table shows "raw material" costs for several aldehyde oil products derived from different sources. This table shows that soybean oil (at nine cents per pound) would be preferred over tall oil (at nine cents per pound) for making aldehyde oils. Tall oil would have a slight advantage over soybean oil for making methyl azelaaldehydate, but soap stock (at five cents per pound) would be an economical source.

Product	Source			
	Margarine oil (9.5¢/lb.)	Soybean oil (9¢/lb.)	Acidulated soap stock (5¢/lb.)	Tall oil fatty acids (9¢/lb.)
	Cost, cents per lb.			
Aldehyde oil, 100% ozonized	18.9	20.3	--	27.8
Aldehyde oil, 33-1/3% ozonized	--	12.1	--	--
Methyl azelaaldehydate	--	22.8	20.0	22.6

The impurity formed in amounts in excess of 15 percent during catalytic hydrogenation of the ozonolysis products obtained from methyl oleate was found to be dimethyl azelaate. This impurity could not be separated from methyl azelaaldehydate or its dimethyl acetal by fractionation through a spinning band column. Pretreatment of the 10-percent palladium-on-charcoal catalyst with hydrogen did not prevent this oxidative degradation of the ozonolysis products. However, use of pyridine-methanol solvent substantially reduced but did not eliminate this undesired side reaction.

Pilot-plant ozonization equipment has been installed and used successfully for preparation of aldehyde oils, methyl azelaaldehydate and related materials.

2. Aldehyde oils and derivatives. Polyesterification studies of the bis (methyl azelaaldehydate) acetal of pentaerythritol with dimethyl terephthalate and ethylene glycol were continued. Sodium carbonate was found to be equivalent to lime as a catalyst in giving soluble, linear polymers. Crosslinking of these polymers was accomplished with p-toluene sulfonic acid, antimony trioxide, and magnesium oxide as well as those catalysts reported earlier. Crosslinking of poly(ester-acetals) has now been effected at temperatures of 100-150° C.

The use of the bis (methyl azelaaldehydate) acetal of pentaerythritol with dimethyl azelaate and hexamethylene diamine for polyamide formation was also explored. Crosslinking of the linear, soluble polyamides, which melt at over 230° C. and have molecular weights of 2,000 to 6,000, was accomplished by heating with p-toluene sulfonic acid. However, the amphoteric oxides that were effective crosslinking agents for polyesters were found to require higher temperatures to crosslink polyamides. The crosslinked polyamides showed strong adhesion to glass as did the crosslinked polyesters.

Studies conducted at the Eastern Division on the plasticizing action of various ester-acetal derivatives indicated that some of them were equivalent to or better than dioctyl phthalate as a plasticizer for polyvinyl chloride. New glyceryl derivatives of azelaaldehydic acid have been prepared and are being evaluated as components of polymers. Products obtained by partial ozonolysis of methyl linoleate and linolenate are now available for characterization.

Potential markets for soybean aldehyde products were estimated by Battelle Memorial Institute, in connection with its contract research on evaluation of these products, at 10 million pounds per year for aldehyde oils and 10-50 million pounds per year for methyl azelaaldehydate. Products prepared at Battelle that justify further evaluation include films obtained by the reaction of polyvinyl alcohol and methyl azelaaldehydate (monoaldehyde oil did not react), surface-active sorbitol and methyl glucoside derivatives, and factice-like products from diamines and dialdehyde oil. Studies comparing the use of free aldehydes and acetals indicated that acetals will usually give superior yields and products.

3. Separation of pure fatty acids. Research to determine the practicability of separating pure fatty acids from soybean and linseed oils is being conducted under a PL 480 grant at the University of Helsinki, Finland. By fractional crystallization without solvents it was possible to obtain considerable changes in the amounts of saturated fatty acids, but changes in the unsaturated ones were not significant. With small amounts of solvents saturated acids could be separated almost completely, oleic acid could be partially separated from linoleic and linolenic acids, but separation of the latter two acids did not appear to be feasible. Results reported to this time have not been encouraging for a solution to the problem of separating linoleic and linolenic acids from soybean and linseed fatty acids by a practical crystallization process. Current studies with zone refining using improved temperature control equipment may be productive.

4. New derivatives. At Queen Mary College, University of London, England, research is in progress on exploration of alkali fusion of unsaturated fatty acids and their derivatives to obtain new, potentially valuable derivatives of soybean and linseed oils. Alkali

fusion of both cis and trans 9,10-epoxystearic acid gave a mixture of mono- and dicarboxylic acids in 60-65-percent yield. Initial opening of the epoxide ring occurred in three ways: hydrolysis, elimination, and reduction. Attempts to arrest alkali fusion of oleic acid at the α,β-unsaturated isomer stage have, so far, resulted in detection of less than 5 percent of the desired product. Addition of a hydride ion donor, butyrolactone, in the alkali fusion of ricinelaidic and oleic acids, led to increased yields of myristic acid. With oleic acid and butyrolactone, both stearic and myristic were formed in amounts equal to 25 percent each of the usual yield for palmitic acid. Palmitic acid is not an intermediate. Effects similar to that of butyrolactone were achieved by use of a small excess of potassium hydroxide.

Research has been initiated at the Experiment Station for the Fats and Oils Industry, Milan, Italy, on studies of the effects of metallic catalysts and physical conditions on the reaction of atmospheric oxygen with soybean and linseed oils and their fatty acids and esters. This information will provide a basis for development of new industrial chemicals from these oils. Orienting experiments on catalysts, analytical methods and apparatus for conducting autoxidations have been performed. A method has been developed for detecting triglyceride peroxides with the aid of "chromatoplates" (silica on glass plates).

PUBLICATIONS AND PATENTS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Chemical Composition and Physical Properties

Cowan, J. C., Cooney, P. M., and Evans, C. D. 1962. Citric acid: Inactivating agent for metals or acidic synergist in edible fats? J. Am. Oil Chemists' Soc. 39(1), pp. 6-9.

Dutton, H. J., Jones, E. P., Scholfield, C. R., Chorney, W.,[1] and Scully, N. J.[1] ([1]Argonne National Laboratory, Chicago, Illinois). 1961. Countercurrent distribution of soybean fatty acid methyl esters biosynthetically labeled with H^3 and C^{14}. J. Lipid Res. 2(1), pp. 63-67.

Evans, C. D. 1961. Chemical changes accompanying flavor deterioration of vegetable oils. Proc. Flavor Chem. Symposium, Campbell Soup Co., pp. 123-146.

Evans, C. D., Cooney, P. M., and Panek, E. J. 1962. Graphic aid for interpreting gas chromatograms. J. Am. Oil Chemists' Soc. 39(4), pp. 210-213.

Frankel, E. N., Evans, C. D., and Cowan, J. C. 1960. Thermal dimerization of fatty ester hydroperoxides. J. Am. Oil Chemists' Soc. 37(9), pp. 418-424.

Frankel, E. N., Evans, C. D., McConnell, D. G., and Jones, E. P. 1961. Analyses of lipids and oxidation products by partition chromatography. Fatty acid hydroperoxides. J. Am. Oil Chemists' Soc. 38(3), pp. 134-137.

Frankel, E. N., Evans, C. D., Moser, H. A., McConnell, D. G., and Cowan, J. C. 1961. Analyses of lipids and oxidation products by partition chromatography. Dimeric and polymeric products. J. Am. Oil Chemists' Soc. 38(3), pp. 130-134.

Frankel, E. N., Evans, C. D., McConnell, D. G., Selke, E., and Dutton, H. J. 1961. Autoxidation of methyl linolenate. Isolation and characterization of hydroperoxides. J. Org. Chem. 26(11), pp. 4663-4669.

Frankel, E. N., McConnell, D. G., and Evans, C. D. 1962. Analyses of lipids and oxidation products by partition chromatography: Hydroxy fatty acids and esters. J. Am. Oil Chemists' Soc. 39(6), pp. 297-301.

Frankel, E. N., Nowakowska, J., and Evans, C. D. 1961. Formation of methyl azelaaldehydate on autoxidation of lipids. J. Am. Oil Chemists' Soc. 38(3), pp. 161-162.

Johnston, A. E., Zilch, K. T., Selke, E., and Dutton, H. J. 1961. Analysis of fat acid oxidation products by countercurrent distribution methods. V. Low-temperature decomposition of methyl linoleate hydroperoxide. J. Am. Oil Chemists' Soc. 38(7), pp. 367-371.

Jones, E. P., Mason, L. H., Dutton, H. J., and Nystrom, R. F.[1] ([1]University of Illinois, Urbana). 1960. Labeling fatty acids by exposure to tritium gas. II. Methyl oleate and linoleate. J. Org. Chem. 25(8), pp. 1413-1417.

Edible Utilization

Dutton, H. J. 1961. Monitoring eluates from chromatography and countercurrent distribution for radioactivity. J. Am. Oil Chemists' Soc. 38(11), pp. 631-636.

Dutton, H. J. 1961. Some applications of mass spectrometry to lipid research. J. Am. Oil Chemists' Soc. 38(11), pp. 660-664.

Dutton, H. J. 1962. Hydrogenation of linolenate. V. Procedure of evaluating hydrogenation catalysts for selectivity. J. Am. Oil Chemists' Soc. 39(2), pp. 95-97.

Dutton, H. J., and Scholfield, C. R. Dec. 12, 1961. Synthetic cocoa butter substitute. U. S. Patent 3,012,890.

Dutton, H. J., Scholfield, C. R., and Jones, E. P. 1961. Separation of geometric isomers and isologues of fatty acid esters by countercurrent distribution. Chem. & Ind. 1961(46), pp. 1874-1876.

Dutton, H. J., Scholfield, C. R., and Mounts, T. L. 1961. Glyceride structure of vegetable oils by countercurrent distribution. V. Comparison of natural, interesterified, and synthetic cocoa butter. J. Am. Oil Chemists' Soc. 38(2), pp. 96-101.

Evans, C. D., Frankel, E. N., Cooney, P. M., and Moser, H. A. 1960. Effect of autoxidation prior to deodorization on oxidative and flavor stability of soybean oil. J. Am. Oil Chemists' Soc. 37(9), pp. 452-456.

Johnston, A. E., MacMillan, D., Dutton, H. J., and Cowan, J. C. 1962. Hydrogenation of linolenate. VI. Survey of commercial catalysts. J. Am. Oil Chemists' Soc. 39(6), pp. 273-276.

Scholfield, C. R. 1961. Countercurrent distribution. J. Am. Oil Chemists' Soc. 38(10), pp. 562-565.

Scholfield, C. R., Jones, E. P., and Dutton, H. J. 1961. Hydrogenation of linolenate. Comparison of products from trilinolenin and methyl linolenate by use of countercurrent distribution and gas-liquid chromatography. Anal. Chem. 33(12), pp. 1745-1748.

Scholfield, C. R., Jones, E. P., Nowakowska, J., Selke, E., Sreenivasan, B., and Dutton, H. J. 1960. Hydrogenation of linolenate. I. Fractionation and characterization studies. J. Am. Oil Chemists' Soc. 37(11), pp. 579-582.

Scholfield, C. R., Jones, E. P., Nowakowska, J., Selke, E., and Dutton, H. J. 1961. Hydrogenation of linolenate. II. Hydrazine reduction. J. Am. Oil Chemists' Soc. 38(4), pp. 208-211.

Scholfield, C. R., Nowakowska, J., and Dutton, H. J. 1961. Glyceride structure of vegetable oils by countercurrent distribution. VI. Corn oil. J. Am. Oil Chemists' Soc. 38(4), pp. 175-177.

Scholfield, C. R., Nowakowska, J., and Dutton, H. J. 1962. Hydrogenation of linolenate. IV. Kinetics of catalytic and homogeneous chemical reduction. J. Am. Oil Chemists' Soc. 39(2), pp. 90-95.

Selke, E., Scholfield, C. R., Evans, C. D., and Dutton, H. J. 1961. Mass spectrometry and lipid research. J. Am. Oil Chemists' Soc. 38(11), pp. 614-615.

Sreenivasan, B., Brown, J. B., Jones, E. P., Davison, V. L., and Nowakowska, J. 1962. Preparation and purity of linoleic acid from commercial corn, cottonseed, and safflower oils. J. Am. Oil Chemists' Soc. 39(5), pp. 255-259.

Willard, J. G., and Martinez, M. L. (Southwest Research Institute, San Antonio, Texas). 1961. The selective hydrogenation of linolenic acid. J. Am. Oil Chemists' Soc. 38(6), pp. 282-286.

Industrial Utilization

Gast, L. E., Cowan, J. C., and Teeter, H. M. Sept. 13, 1960. Protective coating compositions from aliphatic condensed polyunsaturated fatty alcohols and their esters. U. S. Patent 2,952,556.

Miller, W. R., Bell, E. W., Cowan, J. C., and Teeter, H. M. 1961. Pressure reaction of maleic esters with vegetable oils. J. Am. Oil Chemists' Soc. 38(5), pp. 235-237.

Pryde, E. H., Awl, R. A., Teeter, H. M., and Cowan, J. C. 1960. Polyesters from 3,9-bis(7-carbomethoxyheptyl)-2,4,8,10-tetraoxaspiro [5.5]undecane. A new method of crosslinking polyesters. J. Org. Chem. 25(12), p. 2260.

Pryde, E. H., Anders, D. E., Teeter, H. M., and Cowan, J. C. 1961. Ozonization of soybean oil. The preparation and some properties of aldehyde oils. J. Am. Oil Chemists' Soc. 38(7), pp. 375-379.

Pryde, E. H., Awl, R. A., Teeter, H. M., and Cowan, J. C. 1962. Condensation polymers from 3,9-bis(7-carbomethoxyheptyl)2,4,8,10-tetraoxaspiro/5.5/undecane. I. Poly-(ester-acetals) and a novel method for crosslinking them. J. Polymer Sci. 59(167), pp. 1-11.

Pryde, E. H., Moore, D. J., Teeter, H. M., and Cowan, J. C. 1962. Condensation polymers from 3,9-bis(7-carbomethoxyheptyl)-2,4,8,10-tetraoxaspiro/5.5/undecane. II. Poly(amide-acetals). J. Polymer Sci. 58(166, pt. 1), pp. 611-620.

Teeter, H. M., Cowan, J. C., Gast, L. E., Yurgen, W. J.,[1] and Clark, R. A.[1] ([1]Battelle Memorial Institute, Columbus, Ohio). 1961. Safflower oil adducts as plasticizers. J. Am. Oil Chemists' Soc. 38(3), pp. 117-120.

Thierfelder, C. M., Teeter, H. M., and Cowan, J. C. 1962. Preparation of foams from vegetable oil derivatives. J. Am. Oil Chemists' Soc. 39(4), pp. 215-217.

General

Cowan, J. C. 1961. Twenty years of research in oils at Northern Regional Research Laboratory. J. Am. Oil Chemists' Soc. 38(5), pp. 12-14, 16-18.

SOYBEANS FEED, FOOD, AND INDUSTRIAL USES FOR MEAL AND PROTEIN
Northern Utilization Research and Development Div., ARS

Problem. Production of soybeans continues to increase rapidly and is expected to be about 700 million bushels in 1962. For profitable disposition, now and in the future, of the growing supplies of meal from U. S. soybeans, improved feed products and new food and industrial uses are needed. Europe is developing a mixed-feed industry that needs high-protein concentrates. This market could approach that in the U. S. which uses high-protein meal from 400 million bushels of soybeans. For U. S. soybeans to achieve the maximum share of this market, more fundamental information is needed on the proteins and other nutritionally important constituents of soybeans and on the effects of processing on these components. Such information should make possible the production of feeds from soybeans having maximum feeding value that would meet the requirements of foreign markets as well as help maintain or increase the use of soybean feeds in the U. S.

U. S. soybeans could play a dominant role in alleviating the world shortage of dietary protein if more information were available on utilizing soybeans and soybean meal, flour, protein and protein concentrates in food products tailored to meet the nutritional and palatability requirements of foreign markets. That the possibilities are very real for increased utilization of soybeans in foreign foods is indicated by recent work of the Department that showed how to use U. S. soybeans for Japanese foods. The result of this work was that a market for selected soybeans for Japan was opened that now exceeds one million bushels per year. If U. S. soybeans are to achieve the maximum share of foreign food markets, basic information on nutritionally important components and effects of processing on these components will be needed. In addition, better knowledge will be required of how to use soybean protein products in foodstuffs that will be acceptable abroad.

Opportunities also exist for developing new or improved products from soybean meal and protein for industrial use in adhesives, surfactants, emulsifiers, viscosity improvers, and related products. For example, a successful method for stabilizing soybean protein against microbial attack could result in regaining the market for soybean protein as viscosity improvers for water-base paints or as emulsifiers for asphalt. This potential could be realized if more basic information were available on the physical and chemical properties and chemical reactions of components of soybean meal.

USDA PROGRAM

The Department has a continuing long-range program involving organic and physical chemists and biochemists engaged in basic research on the characterization of components of soybean meal and protein and application of the knowledge gained to solution of problems encountered in processing and utilization of soybean meal and protein. This research is conducted at Peoria, Illinois.

The Federal scientific effort on utilization of soybeans and soybean meal and protein totals 8.0 professional man-years. Of this number 7.0 are devoted to chemical composition and physical properties and 1.0 to food products.

Research on chemical composition and physical properties involves basic studies on isolation and characterization of components of whey proteins and acid-precipitated proteins. Research on food products is devoted to development of information on specially processed protein products pertinent to their use in foods for foreign markets. The current program does not include research on industrial products. During the reporting period research on stabilization of soybean protein against microbial attack encountered in certain industrial uses was placed in abeyance to permit assignment of personnel to other important research.

The Department also sponsors research on utilization of soybeans (15.9 professional man-years) conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition and physical properties (5.2 professional man-years) involves grants to the University of Edinburgh, Scotland, for investigations on polysaccharides of soybeans (3.2 professional man-years) and to the Weizmann Institute of Science, Rehovot, Israel, for research on complexes between soybean protein and other components of the meal (2.0 professional man-years). Research on food products (7.0 professional man-years) involves grants to the National Institute of Nutrition, Rome, Italy, for studies on use of soybean protein in pasta (3.0 professional man-years); and to the Central Miso Institute, Tokyo, Japan, for studies on miso made from dehulled soybean grits (3.0 professional man-years). Also, a contract, financed with PL 480 funds, has been placed with the Japan Shoyu Institute, Tokyo, Japan, for comparative evaluations of soy sauces prepared from Japanese and U. S. soybeans (1.0 professional man-year). Research on feed products (3.7 professional man-years) involves a grant to the Hebrew University, Rehovot, Israel, for basic studies on soybean saponins.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported 1.6 professional man-years divided among subheadings as follows: chemical composition and physical properties, 1.1; feed products, .1; and processing technology, .4.

Research dealing with the chemical and physical properties of soybean proteins involves separation and purification of the albumin and globulin proteins to establish amino acid sequence, molecular weight and peptide structure of individual purified proteins. Other stations are doing breeding and evaluation work with soybeans and a portion of this research includes testing and evaluating the meal and protein content of varieties. The program involving feed products deals largely with nutritive value considerations and the use of meal in animal rations. Research on processing technology centers around a process for the recovery of oil from oil-bearing seeds which is being developed. The process involves combination of the several unit operations of mixing, grinding, centrifugation, and decantation in a unique manner. Residual meals are evaluated.

Industry and other organizations maintain an interesting and vigorous program in this research area. Research on soybean meal and protein is conducted principally by soybean crushers and processors. Manufacturers of specialty foods and dietary products also contribute. The largest share of the companies' research effort is directed towards food products. Considerably smaller but approximately equal shares are devoted to basic research, processing research, research on feed products, and research on industrial products. Some cooperative work is performed in evaluation of processes and products developed by the Department. Except for such cooperative work, the exact nature of the research performed and the results are kept confidential or patented by the companies. Estimated annual expenditures by industry for research on soybean meal and protein products are equivalent to approximately 20 professional man-years in basic research, 40 professional man-years in applied and developmental research on food products, 15 professional man-years in research on feed products, 15 professional man-years in applied and developmental research on industrial products, and 20 professional man-years in processing research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Acid-precipitated protein. The major component (11S protein) of acid-precipitated protein has been purified by ammonium sulfate precipitation. The starting material used is the cold-insoluble fraction of soybean protein which contains 70-75 percent 11S protein plus contaminants having sedimentation constants of 2S, 7S, and 15S. Preparations of 11S protein 91-96 percent pure have been obtained. Purified

11S protein exhibits a molecular weight of 350,000 at pH 7.6 and 0.5 ionic strength; it dissociates into 10 subunits at pH 2.2 and 0.01 ionic strength, and displays reversible aggregation to dimer plus small amounts of higher polymers when ionic strength is increased to 0.05. Freezing and thawing and freeze-drying also result in breakdown into subunits and reaggregation. The 11S protein does not, however, revert to the original distribution of components in the unfractionated mixture. In the course of this work it was noted that the ratio of 7S to 11S components varied with the type of soybean. Whether changes in this ratio are actually varietal or merely environmental has not yet been established.

2. Whey proteins. The removal and recovery of whey proteins by precipitation with anionic detergents and edible gums and partial evaluation of the properties of the precipitates have been completed. The results show that the whey proteins are completely precipitated by selected negative colloids, that essentially all the lipoxidase is present in the precipitate (complex) in an active form, but that an unsaturated fatty acid must be combined with the complex to obtain enzyme activity. Also the amylases were precipitated in an active form, but because of the insolubility of the complex at the pH of optimum activity, the extent of its activity was not fully established. The maximum decrease in the BOD of the whey solution was 18 percent. This procedure may lead to development of commercially feasible processes (1) to isolate active enzyme preparations from the whey and (2) to reduce the manufacturing cost of soybean protein.

By means of improved chromatographic procedures, two trypsin inhibitors (A_1 and A_2) were isolated from whey protein in 96-percent purity. They were compared with commercial Kunitz (K) inhibitor of at least 95-percent purity. Molecular weights of A_1, A_2, and K determined in the ultracentrifuge were 14,000, 21,600 and 22,700. These and other physical data indicate that A_1 is different from A_2 and suggest that A_2 and K are the same. The specific activities toward trypsin for the three are in the ratio 1.6:1.0:1.0; however, the molar ratios are 1.0:1.0:1.0, showing a mole-for-mole reaction for each of the three preparations with trypsin. On the other hand, preliminary amino acid assays of A_2 and K show that inhibitor K is significantly higher in isoleucine, glycine, valine, tryptophane, and glutamic acid content. The N-terminal residue for all three inhibitors is aspartic acid. Preparation A_1 is an entirely new trypsin inhibitor. Further study will be needed to determine if compositional differences between A_2 and K are a matter of impurities or of identity.

Factors responsible for growth inhibition and pancreatic hypertrophy of rats fed raw soybean meal were readily destroyed by autoclaving for 15 minutes at atmospheric pressure and 100° C. Assay by growth rate of rats was maximum even with 120 minutes of autoclaving at one atmospheric pressure with live steam. Initial moisture of 5 and 20

percent had no effect. These results are not in agreement with previous work that showed 30 minutes autoclaving at atmospheric pressure was required for maximum growth and that there was a decline in growth with heating beyond 60 minutes. Our results explain the high degree of uniformity in nutritive value of eight commercial meals obtained from five processors even though processing conditions of temperature, time and moisture varied considerably. Assay of soybean meal fractions, residue, acid-precipitated protein, whey solids, and isolated whey proteins showed that autoclaving was required for maximum growth rate and to prevent pancreatic hypertrophy. Factors responsible for growth inhibition and pancreatic hypertrophy are concentrated in the whey fractions. Growth inhibition and pancreatic hypertrophy with rats fed raw soybean meal can be reversed by switching to casein. Little correlation was found between trypsin inhibitor activity of meal fractions and pancreatic hypertrophy. Poor protein efficiency of isolated protein is corrected by adding methionine. In connection with this work the complete amino acid analyses of soybean meal fractions were determined for the first time. Three of these fractions are commercial byproducts, production of which total at least 400,000 tons annually. Animal feeding tests were conducted in the Pharmacology Laboratory of the Western Division.

3. Soybean polysaccharides. Research at the University of Edinburgh, Scotland, has resulted in the isolation of a pure galactomannan consisting of a main chain of mannose units with galactose attached to every third mannose unit.

B. Food Products

1. Reversible gels from soybean protein. It was discovered that ethanol washing of the acid-precipitated protein enhances its foaming properties. Further work showed that alcohol washing removes an "antifoaming agent(s)" and that alcohol denaturation of the protein is not responsible for the increased foaming properties. Removal of the antifoaming agent by alcohol washing was markedly dependent upon alcohol concentration; 86 percent aqueous concentration was most efficient for ethanol. Acid-precipitated protein washed with this concentration of alcohol can be whipped into a foam which is 30-40 times as stable as the foam from unwashed protein or commercial soybean whipping agents. Heat-reversible gels form when 6-10 percent neutral solutions of alcohol-washed protein are heated and then cooled. Studies suggest antifoaming and gelling agent(s) is(are) phospholipide(s). Aqueous methanol (95 percent) and aqueous isopropanol (82 percent) were as effective as 86 percent ethanol for washing acid-precipitated soybean protein to improve foaming properties of the protein.

Development of unusually stable foams or heat-reversible gels from soybean protein may lead to increased industrial and food use of this protein; for example, these foams may prove important in foam mat

drying. Evaluation tests of these foams in drying orange juice are in progress at the U. S. Fruit and Vegetable Products Laboratory, Winter Haven, Florida.

2. Comparison of United States and Japanese soybeans for soy sauce. Quantitative data have been reported on the preparation of soybeans, wheat koji and other steps leading to the fermenting stage in manufacture of soy sauce at 11 different processing plants. Significant results on yields and quality of shoyu cannot be given until after the fermenting stage which will last for several months. This research is being conducted by the Japan Shoyu Institute, Tokyo, Japan.

C. Industrial Products

1. Stabilization of soybean meal fractions against microbial attack. In continuation of studies to increase industrial utilization of soybean meal and protein by stabilization to attack by microorganisms, the following chemicals were reacted with defatted soybean meal under one or more sets of conditions: (1) carbon disulfide, (2) ethylene oxide, (3) butylene oxide, (4) phenyl isocyanate, (5) maleic anhydride, (6) potassium thiocyanate, (7) phthalic anhydride, (8) acrylonitrile, and (9) glycidyl methacrylate. Similar reactions were effected on α-protein and sodium proteinate. Several of above reactions were effected on the residue from protein isolation and soybean whey proteins. Stability of the reaction products was tested by measuring the change in pH and viscosity of the reaction products and time for the development of putrefaction after inoculation with soil. Effect of addition of formaldehyde on viscosity was determined. None of the reaction products was stable to putrefaction more than 4 days after inoculation with soil. Products which showed the greatest stability to microorganisms and showed little or no change in viscosity of the protein on addition of formaldehyde were the reaction products of ethylene and butylene oxide, maleic and phthalic anhydride, phenyl isocyanate and acrylonitrile. The ethylene oxide reaction product with α-protein was very unusual in that it was soluble in the pH range of 1.8-12.0. Use of a chemical preservative, such as formaldehyde, after appropriate chemical modification of the protein has the greatest promise for industrial utilization where extended stabilization is important. This research has been placed in abeyance to permit assignment of personnel to more urgent work.

D. Feed Products

1. Effects of saponin on nutritional quality of soybean feeds and foods. A critical review of the literature has been made, methods for extracting saponins from soybeans have been devised, and assay methods for the quantitative determination of soy saponins have been established. Experiments show that autoclaving soybean meal destroys most of the

hemolytic activity of the saponins present, but autoclaving isolated saponin preparations had no effect on this biological response. These results indicate that cooking soy food and feed products may be important to inactivating the suspected "toxic" effects of saponins in these products. This research is being conducted by the Hebrew University, Rehovot, Israel.

PUBLICATIONS AND PATENTS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Chemical Composition and Physical Properties

Mayer, F. C., Campbell, R. E., Smith, A. K., and McKinney, L. L. 1961. Soybean phosphatase. Purification and properties. Arch. Biochem. Biophys. 94(2), pp. 301-307.

Rackis, J. J., Anderson, R. L., Sasame, H. A., Smith, A. K., and VanEtten, C. H. 1961. Amino acids in soybean hulls and oil meal fractions. J. Agr. Food Chem. 9(5), pp. 409-412.

Smith, A. K., and Nash, A. M., with the technical assistance of Wilson, L. I. 1961. Water absorption of soybeans. J. Am. Oil Chemists' Soc. 38(3), pp. 120-123.

Weakley, F. B., Eldridge, A. C., and McKinney, L. L. 1961. The alleged "thiamine-destroying factor" in soybeans. J. Agr. Food Chem. 9(6), pp. 435-439.

Wolf, W. J., Babcock, G. E., and Smith, A. K. 1961. Ultracentrifugal differences in soybean protein composition. Nature 191(4796), pp. 1395-1396.

Food Products

Black, L. T., Kirk, L. D., and Mustakas, G. C. 1961. The determination of residual alcohol in defatted alcohol washed soybean flakes. J. Am. Oil Chemists' Soc. 38(9), pp. 483-485.

Hesseltine, C. W., and Shibasaki, K.[1] ([1]Tohoku University, Sendai, Japan). 1961. Miso. III. Pure culture fermentation with Saccharomyces rouxii. Appl. Microbiol. 9(6), pp. 515-518.

Mustakas, G. C., Griffin, E. L., Jr., and Kirk, L. D. Feb. 27, 1962. Production of undenatured debittered soybean product. U. S. Patent 3,023,107.

Mustakas, G. C., Kirk, L. D., and Griffin, E. L., Jr. 1961. Bland undenatured soybean flakes by alcohol washing and flash desolventizing. J. Am. Oil Chemists' Soc. 38(9), pp. 473-478.

Mustakas, G. C., Kirk, L. D., and Griffin, E. L., Jr. 1962. Flash desolventizing defatted soybean meals washed with aqueous alcohols to yield a high-protein product. J. Am. Oil Chemists' Soc. 39(4), pp. 222-226.

Shibasaki, K.,[1] and Hesseltine, C. W. ([1]Tohoku University, Sendai, Japan). 1961. Miso--I. Preparation of soybeans for fermentation. J. Biochem. Microbiol. Technol. Eng. 3(2), pp. 161-174.

Shibasaki, K.,[1] and Hesseltine, C. W. ([1]Tohoku University, Sendai, Japan). 1961. Miso. II. Fermentation. In "Developments in Industrial Microbiology," Vol. II, pp. 205-214, Plenum Press, Inc., New York, N. Y.

Smith, A. K., Hesseltine, C. W., and Shibasaki, K.[1] ([1]Tohoku University, Sendai, Japan). Jan. 3, 1961. Preparation of miso. U. S. Patent 2,967,108.

Smith, A. K., Watanabe, T., and Nash, A. M. 1960. Tofu from Japanese and United States soybeans. Food Technol. 14(7), pp. 332-336.

Smith, A. K., and Wolf, W. J. 1961. Food uses and properties of soybean protein. I. Food uses. Food Technol. 15(5), pp. 4-6, 8, 10.

Wolf, W. J., and Smith, A. K. 1961. Food uses and properties of soybean protein. II. Physical and chemical properties of soybean protein. Food Technol. 15(5), pp. 12-13, 16, 18, 21, 23, 26, 28, 31, 33.

General

Cowan, J. C., and Witham, W. C. 1961. Research progress in soybean utilization 1959-61. Soybean Digest 22(2), pp. 12-14.

Djien, K. S.,[1] and Hesseltine, C. W. ([1]Bandung Institute of Technology, Bandung, Indonesia). 1961. Indonesian fermented foods. Soybean Digest 22(1), pp. 14-15.

Rackis, J. J., and Cowan, J. C. 1960. Progress in soybean protein utilization. Soybean Digest 21(1), pp. 14-17.

Smith, A. K. 1961. Oriental methods of using soybeans as food. With special attention to fermented products and notes on oriental farming practices. U. S. Dept. Agr. ARS-71-17, 65 pp.

REPLACEMENT CROPS UTILIZATION POTENTIAL
Northern Utilization Research and Development Div., ARS

Problem. Farmers could achieve more economic use of their land if new and profitable crops were available for their choice that would have different end-use patterns from those presently grown. For example, it would be advantageous to develop a new oilseed crop yielding unique fatty acids that could find industrial use in applications for which acids from presently available domestic oilseed crops are unsuitable. To develop a new crop, three basic steps are involved: (1) survey of wild plants, in cooperation with plant scientists, to identify those having both potentially valuable components and promising agronomic potential for use in the United States; (2) detailed physical and chemical characterization of components of interest to obtain clues to likely end uses; (3) selection of the most promising species followed by additional utilization research to explore uses and demonstrate industrial potential and by additional agronomic research to establish proper cultural practices and to select the best strains and varieties. Only after these steps have been successfully accomplished can a proposed new crop be offered to agriculture and industry for introduction and development. Obviously, a program of this type is a long-range one. Yet, whether the future of agriculture involves conditions of surplus, of greater emphasis on foods and feeds, or of necessity for greater national self-sufficiency, the nation will benefit from availability of optimum, practical crop plants to serve its needs.

To achieve the objective, survey and characterization work needs to be greatly increased, since the greater the number of species examined, the greater will be the opportunities for finding plants meeting the criteria of high utilization and agronomic potentials. Work of the Department has already revealed several promising sources of new potentially valuable water-soluble gums, pulp fibers, and oils containing unique fatty acids such as hydroxy-unsaturated acids, capric acid, epoxidized acids, and unusual long-chain fatty acids. In order to demonstrate the potential of these new materials, further work is required on their physical and chemical properties and reactions, on processing to obtain maximum recovery from source plants, and on by-products from processing, such as oilseed meals.

USDA PROGRAM

The Department conducts a long-range continuing program of research involving analytical and organic chemists and chemical engineers engaged in examination of uncultivated plants to find unusual and potentially useful components and in detailed characterization and evaluation studies of selected components that have the greatest

industrial potential and that are obtainable from agronomically promising plants. Plants or seeds for this program are obtained by cooperation with Crops Research Division which procures material from domestic and foreign sources by means of collecting trips or from experimental plantings. Materials from abroad are also made available through Crops Research Division PL 480 projects providing for collecting activities by foreign investigators. All seeds and plants are submitted to a broad chemical-screening program to identify sources of unusual and potentially useful components such as oils, fibers, gums, amino acids and proteins. Components of interest from plants rated by Crops Research Division as having a reasonable agronomic potential for the United States are characterized to obtain clues to areas of utilization of probable interest to industry. On the basis of the results, plants having the highest agronomic potential and containing components of greatest potential industrial value are selected for more intensive utilization research. This utilization research is divided among the four Utilization Research and Development Divisions.

The Federal scientific effort devoted to research on replacement crops at Peoria, Illinois, totals 19.7 professional man-years. Of this number, 11.7 are concerned with chemical composition and physical properties; 6.2 with industrial utilization of new oilseeds; and 1.8 with industrial utilization of new gum and fiber plants.

Research at Peoria, Illinois, on chemical composition and physical properties (19.4 professional man-years) involves conduct of the program on screening uncultivated plants for unusual and potentially useful oils, fibers, gums, amino acids and other components; organic chemical characterization of selected fractions and components, especially new oils fatty acids; and studies on properties of new plant fibers. During the reporting period, specific projects on screening for proteins were discontinued because this work can be conducted more effectively as part of the screening programs for new oilseeds and amino acids. A research contract (.3 professional man-year) is in effect with Montana State College, Bozeman, Montana, providing for screening and analysis of seed oils of Brassica (mustard) and related genera to identify species having greatest erucic acid content and agronomic potential.

Research at Peoria, Illinois, on industrial utilization of new oilseeds (6.2 professional man-years) involves studies on processing of erucic acid oilseeds to obtain oil and meal and investigations on utilization of erucic acid and its derivatives.

Research at Peoria, Illinois, on industrial utilization of new gum and fiber plants (1.8 professional man-years) is concerned with development of methods for recovery of gums from plants; with evaluation of plant gums in industrial application; and with studies on pulping new

fiber plants and evaluation of the pulp in paper, structural boards and related products. During the reporting period research on utilization of Crotalaria intermedia gum was completed.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 3.7 professional man-years divided between subheadings as follows: chemical composition and physical properties, 2.2; industrial utilization, 1.5. The Hawaii Station is making assays of the native and introduced tropical plants in a search for products of economic value. Other station research involves screening studies of the chemical composition of many domestic and exotic plants. A study which is cooperative with USDA is seeking ways to modify or improve methods of retting fiber crops. Methods are sought which will yield maximum fiber of high, uniform quality. Industrial utilization of replacement crops is the subject of effort devoted to determining possibilities for industrial use for a number of domestic and imported crops. High oil-producing crops, which produce oils of specific character, are actively being sought and their potential evaluated.

Industry and other organizations conduct significant research on replacement crops. Several industrial companies are interested in the utilization of materials derived from foreign or potential new domestic crops for solving special problems encountered in their operations. Some companies sponsor experimental plantings in the United States. Others are not interested in possible domestic production of crops but intend to produce and use materials in foreign operations. Still others investigate materials from foreign crops for use within the United States. Commodities of interest include plant gums, new pulp fibers, and oilseeds containing unusual oils and fatty acids. The companies' research in these areas is largely devoted to process and product development and evaluation studies. Some effort is placed on basic research, especially on plant gums. A good share of the industrial research effort is concerned with cooperative evaluation and testing of products now being studied for utilization potential by the Department. Except for cooperative work, the exact character and results of the companies' research is kept confidential or patented.

A small research effort related to utilization potential of replacement crops is expended by universities. Basic research is concerned with development of methodology for analysis of certain unusual fatty acids and with study of the effects of these acids in animal feeding. Applied research involves study of utilization of an oil from a new oilseed in protective coatings. Estimated annual expenditures for research on replacement crops are equivalent to approximately 7.0 professional man-years in basic research, 10.0 professional man-years in applied and developmental research on new pulp fibers, 15.0 professional man-years in applied and developmental research on plant gums, and 6.0 professional

man-years in applied and developmental research on unusual oils and fatty acids.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Screening for new industrial oils. Since the last report 1,087 additional samples of seeds were screened for new oils of potential industrial interest. Lesquerellae. All but two of fourteen species tested produced mainly the C-20 hydroxy acid (lesquerolic acid) analogous to ricinoleic acid. The two exceptional species produced a C-18 hydroxy acid. Crop potential of Lesquerellae is good. Industrial possibilities for utilization of lesquerolic acid appear attractive; e.g., this acid can be readily converted to dodecanedioic acid, a C-12 dibasic acid that merits evaluation as an intermediate for resins, plasticizers and lubricants.

Cupheae. Two species of Cuphea contained over 80 percent of capric acid. A third species contained 57 percent of lauric acid (compare 44-52 percent for coconut oil). Large quantities (over 600 million pounds) of coconut oil are imported each year because of its content of lauric, capric and other acids having fewer than 18 carbon atoms in their chains; hence a domestic source of such acids would be valuable. Unfortunately crop potential of the Cuphea genus has not proven to be promising. Hopefully, continued screening may reveal other genera rich in short chain acids.

Erucic acid oils. Some 270 seed samples of Cruciferae have so far been analyzed during the contract research at Montana State College. Two samples of Brassica chinensis (Chinese cabbage; good crop potential) seed showed 48-50 percent of oil and 21-22 percent of protein. The oil contained 48-51 percent of erucic acid. However, no species or variety has been encountered that contains as much or more erucic acid in its oil than Crambe abyssinica (28-36 percent oil containing 56-59 percent erucic acid; 23-29 percent protein).

Miscellaneous unusual oils. Many seed oils containing unusual fatty acids or other uncommon components were revealed by the screening program. Space permits mention of only a few of the more interesting results. The following examples will, however, serve to illustrate the remarkable variety of constituents observed in uncultivated oilseeds. Several Cruciferae contained up to 58 percent of eicosenoic acid, a C-20 monoene acid. An aster oil contained trans unsaturation and 12 percent of a C-16 monoene acid (apparently not palmitoleic acid). Comandra pallida seed oil contained 45 percent of ximenynic acid. This is the first domestic source observed to contain substantial amounts of an acetylenic acid. Oil from Osyris alba (sandalwood family, Turkey)

contained 59 percent of ximenynic acid. A source containing 36 percent of an unidentified triene acid having trans unsaturation, previously observed in several aster species and burdock, was found in Calea urticae-folia (sunflower family). This acid is different from the triene acid of Thalictrum.

Seed oil of Melochia charantia (from Mexico) contained 50 percent of conjugated triene. Tetraenoic acids were observed in oil from Lappula redowski and in several other borage oils. Dalea oils contained 28 percent of unsaponifiables high in xanthophyll. The lipid extract from seed of Briza spicata, a Turkish grass, was a greasy solid that did not melt on the steam bath. It contained 1.6 percent of nitrogen and 3.0 percent of phosphorus but only 50 percent of fatty acids. Tests also showed presence of major amounts of sugars.

2. Studies on oilseed meals. The economic value of any new oilseed crop would be greatly enhanced if it yielded a nutritious, high-protein meal for animal feed. During the reporting period special attention was paid to minor constituents that might be deleterious to feeding value, especially isothiocyanates and oxazolidenethiones of crucifers. ("Oxazolidenethiones" are sometimes less precisely named "thiooxazolidones.") Seven samples (four locations) of Crambe abyssinica grown by the NC-7 Committee (North Central Regional Committee on New Crops) produced extracted meals containing from 1.7 to 2.5 mg. of isothiocyanate (calculated as butenyl) per gram of meal (seeds not hulled) and 3.0 to 5.5 mg. of oxazolidenethione. Seven samples of Eruca sativa from the same locations contained from 18.2 to 19.9 mg. isothiocyanate (as butenyl) per gram of extracted meal except for one (probably immature) sample that contained 11.1 mg. E. sativa contained no oxazolidenethione. Extracted meal from two samples of Lesquerella lasiocarpa contained 6.9 and 7.4 mg. of volatile isothiocyanate, while three other species ranged from 2.4 to 3.9 mg./g. No oxazolidenethione was found in the Lesquerella seed examined.

Certain heat-processed seed meals from Brassica juncea showed considerable losses in lysine and in some cases histidine and arginine, indicating the need for care in establishing heating conditions. Several unfamiliar amino acids were indicated in meals from Acacia willardiana, Acacia farnesiana, and Lysiloma desmostachys. Meal from Sesbania macrocarpa showed some promise as feed material, even when fed raw to rats and mice; that from Limnanthes douglasii maintained life, but permitted little growth; and Clitoria ternatea meal appeared to be toxic. Best results with all three meals were obtained after heating. The poor results with L. douglasii may be attributable to bulkiness or other factors rather than to protein quality. Further testing is in progress on L. douglasii and S. macrocarpa. Studies have begun to investigate possible solvent systems for removal of thioglucosides

from Crambe and to develop improved analytical methods for thioglucosides. Lunaria annua meal prepared by the Northern Division detoxification process was nontoxic and nutritious in feeding tests with rats at the Western Division.

3. Screening for amino acids. Evaluation was made of results of amino acid analysis on seeds of 200 plant species in 181 genera in 61 families. Previous indications were confirmed that the amino acids showing greatest variability, other than hydroxyproline, were lysine, methionine, arginine, glutamic acid, and proline. Leguminosae tend to be high in lysine and low in methionine; Compositae, low in lysine and high in methionine; and Cruciferae, high in lysine and average in methionine. A mean of 85.6 percent of the nitrogen was accounted for as common amino acids and ammonia and 3.4 percent in insoluble humin leaving 11 percent unidentified or undetected. Additional determinations of amino acid composition revealed a seed meal from one species, Cephalotaxus harringtonii, that contained 31 percent protein high in lysine (6.6 g./16 g. N), methionine (2.3 g./16 g. N), and four additional essential amino acids. This species has, however, little potential for crop development.

Further studies were made of the hydroxyproline content of seed meals, seedcoats, and pericarps. Hydroxyproline was found in 123 of 183 seed meals analyzed, to the extent of 0.1 to 5.7 g./16 g. N. Eight samples of seedcoat and pericarp contained from 3.1 to 10.0 g./16 g. N. In 16 seed meals derived from kernel alone there was no hydroxyproline. Solubility studies indicated that hydroxyproline was a part of plant protein, an observation of fundamental importance since this amino acid had hitherto not been considered to be a constituent of normal plant protein.

4. Screening for new seed mucilages. All species of Crotalaria available at the Northern Division have been surveyed for mucilage content. None was superior in yield to C. intermedia except C. spectabilis which has two disadvantages--dark color and extreme toxicity. Thirty-seven new species of seed have been surveyed for mucilage content. Two Cassia species containing 29 to 32 percent water-soluble mucilage in the seed are reported to produce 1,837 pounds per acre (C. occidentalis) and 2,875 pounds of seed per acre (C. bonariensis).

5. Screening for new pulp fiber plants. One-pound pulping experiments were performed on 61 raw materials to investigate the relationships among compositional and botanical characteristics and pulping properties. Data were collected on pulp yield, chemical consumption, permanganate number, ease of refining, pulp freeness, and strength values of handsheets from the pulps. Statistical evaluation resulted in a number of significant and interesting conclusions. A few of

these are: (a) Given equivalent kraft pulping treatments, grasses are more completely pulped than dicotyledons as indicated by extent of delignification. (b) Pulps from grasses contain more pentosan, primarily because of larger amounts present in the starting materials; percentage removal on pulping is the same as with dicotyledons. (c) Differences in alkali solubility are considerably more statistically significant than are differences in cellulose content when plant groups are compared with one another; alkali solubilities parallel differences in pulp yield. (d) Plants of the mallow family yield pulps that refine easily and form paper with high fold and burst values. (e) Fiber dimensions are not as closely associated with sheet strengths as expected. (f) Within plant families (contrast with point c) α-cellulose content is the property that would serve as the best single criterion for predicting both pulp yield and pulp quality for a given species. One species each of Sesbania, Crotalaria, Hibiscus, and Andropogon, as well as a new okra variety, had superior pulping possibilities in comparison with other new samples screened.

6. Characterization of new seed oils and components. Lunaria biennis seed oil was shown to contain 21 percent of cis-15-tetracosenoic acid (C-24) in addition to 42 percent of erucic acid. This oil might be a practical source of the C-24 acid since it is readily separated from erucic acid by distillation. Hibiscus syriacus seed oil was found to contain over 16 percent of malvalic acid plus 3.4 percent of sterculic acid (C-18 and C-19 cyclopropenoid acids, respectively). This species is the richest herbaceous source of cyclopropenoid acids yet found. In addition, both malvalic and sterculic acids were found in several species thought to contain only one of these acids. These acids are important because they are reactive acids that should have high industrial potential if good sources can be found. They also have important physiological properties when found in trace quantities in poultry feed.

The triene acid in Thalictrum polycarpum seed oil (35 percent of acids) has been identified as trans-5,cis-9,cis-12-octadecatrienoic acid. The "hydroxy" acid in Ipomoea sp. seed oil is (+)-11-hydroxyhexadecanoic acid. The new hydroxy fatty acid in Lesquerella densipila oil (35 percent of the seed oil) has been characterized as 12-hydroxy-cis-9,cis-15-octadecadienoic acid. The discovery of a naturally occurring long-chain acid having hydroxyl function located between two double bonds and constituting a major component of a seed oil again extends the range of raw materials that can be obtained from higher plants.

The glycolipid component of Ipomoea parasitica seed oil is an acylated glycoside of (+)-11-hydroxypalmitic acid which on the average contains two sugar (monosaccharide) units per molecule. Physical and chemical properties have been determined for oils; fatty acids, alcohols and methyl esters; liquid and solid wax esters; and hydrogenated triglycerides from Crambe abyssinica and Lunaria annua (biennis). The wax esters were recovered in yields of about 80 percent of theory based on oil.

B. Industrial Utilization of New Oilseeds

1. Processing mustard and other erucic acid oilseeds. By a suitable sequence of operations it has been found possible to integrate an efficient detoxification step into the conventional filtration-extraction method for recovering oil and meal from oilseeds. After cracking and flaking, mustard seed was moisturized and held at a moderate temperature to permit natural enzymatic hydrolysis of the glucoside to liberate allyl isothiocyanate. The wet meal was then heated and cooked with simultaneous removal of the allyl isothiocyanate by distillation. After cooling, the crisped meal was re-rolled, and submitted to filtration-extraction. Remaining traces of allyl isothiocyanate were removed from recovered oil by conventional refining techniques and from the meal by a final treatment with live steam. With cooperation of the Southern Division large batches (up to 500 pounds) of mustard seed were processed in the pilot plant by the process described. Whereas the original seed contained 0.92 percent of allyl isothiocyanate, the detoxified meal contained 0.004 to 0.007 percent and the refined oil contained no detectable allyl isothiocyanate.

With the initially developed process just described, recovery of allyl isothiocyanate and lysine content of the meal were unsatisfactory. These problems have been substantially overcome by reducing the enzyme hydrolysis period (liberation of allyl isothiocyanate from its glycoside), sparging with steam to remove the volatile oil, and reducing the overall heating period. Rat-feeding tests conducted at the Western Division with mustard meal produced by the Northern Division integrated process showed that the mustard meal was nontoxic and was utilized quite well, although not quite equal to commercial soybean meal. Thyroid tissues taken in autopsies showed no evidence of enlargement even when the animals had been fed a ration containing 0.4 percent of allyl isothiocyanate. In laboratory trials detoxification has also been integrated successfully with the prepress-solvent extraction process.

Processing studies were initiated on Crambe abyssinica seed to test the integrated filtration-extraction procedure on this species. Meals were obtained that contained no detectable oxazolidenethione and little (0.005 percent) allyl isothiocyanate. The apparent elimination of oxazolidenethione in Crambe meal should be regarded with considerable caution. The mechanism and products of decomposition of oxazolidenethione during processing are not known. Absence of oxazolidenethione does not necessarily signify absence of toxicity. A supply (10 pounds) of Crambe meal, shown by presently available analytical techniques to contain no oxazolidenethione and negligible isothiocyanate, has been sent to the Western Division for feeding tests. Except for completion of cost analysis, study of processing of ordinary mustard seed is essentially complete. Emphasis will now be placed on Crambe processing and the resulting fate of oxazolidenethione.

2. Utilization of erucic acid. Erucic acid of 90-percent purity was produced from fatty acids prepared from Crambe abyssinica oil (50 percent erucic acid) by liquid-liquid extraction, followed by distillation. Ozonization of methyl erucate and reductive cleavage of the ozonides gave a 75-percent yield of methyl brassylaldehydate of 95-percent purity. Similar procedures applied to mustard seed oil gave an 88-percent yield of an aldehyde oil containing 2.67 carbonyl groups per molecule. Workable procedures for preparing pound quantities of brassylic acid (97.5 percent pure) from erucic acid have been developed and samples have been submitted to the Western Division for evaluation in shrink-proofing of wool.

C. Industrial Utilization of New Gum and Fiber Plants

1. Crotalaria gum. A dry-milling procedure was developed for milling Crotalaria intermedia in which the whole seed is passed through a pin mill at 18,000 r.p.m. to shatter the hull and pulverize the germ, leaving the gum in the form of relatively coarse particles retained on a 40-mesh screen. The fines are separated from the coarse gum particles by air classification or by screening, or a combination of these. By flaking of the +40-mesh particles in a roller mill and grinding in a hammer mill, the gum is reduced to flour (-100-mesh screen) for use-testing. In color and viscosity of solutions, the recovered gum was similar to commercially available guar gum. A steaming procedure for enzyme inactivation was devised which prevents the rapid loss of viscosity of solutions of Crotalaria gum. Inclusion of a tempering step in the processing gave up to a twofold increase in viscosity of the solutions. This dry-milling process has also been utilized successfully for isolating gum from seeds of guar and Cassia marilandica (a legume). Yields of gum are 23.5 percent from Crotalaria and guar and 27.5 percent from Cassia. In preliminary tests as a wet-end additive for softwood kraft and sulfite paper pulps, Crotalaria gum gave results equal or superior to guar gum in improving burst, tensile strength, and fold properties of paper handsheets.

2. Kenaf for pulp and paper. Based on the results of screening tests of several hundred plant species as possible sources of nonwood pulps and on the evaluation of the agronomic potential of these plants by Crops Research Division botanists and agronomists, kenaf and related Hibiscus species were selected for more detailed evaluation of their industrial potential.

Yields of unbleached and bleached kenaf pulps (about 46 and 41 percent, respectively) from soda and kraft cooking (18 and 21 percent chemical) were comparable to yields of pulps from coniferous wood by the sulfite and sulfate processes. Yields by the neutral sulfite process (54 to 57 percent unbleached and 45 to 51 percent bleached) were substantially less than those for hardwood neutral sulfite semichemical pulps (75 percent unbleached and 58 percent bleached). Values for chemical

consumption in the soda and kraft processes were of the same magnitude (about 85 to 95 percent) as for sulfate pulping of Douglas fir at comparable levels of applied chemical. Chemical consumption by the neutral sulfite process amounted to 72 to 77 percent; however, these values are not directly comparable with available data on neutral sulfite pulping of woods.

Burst and tensile properties of handsheets from the kenaf pulps were substantially comparable to published data for sulfate pulps from Douglas fir. Tear strength of the experimental papers was deficient by comparison, but at a usable level. Data for fold strength approached rather closely the fold data for the Douglas fir pulps. Experimental machine papers from kenaf had strength properties, except for tear, comparable to those of published data for kraft bond papers from Douglas fir.

Kenaf pulp was blended at various levels with representative commercial soft- and hardwood pulps. In most cases properties were intermediate and as anticipated on the basis of percentage composition. Thus, kenaf-hardwood blends had superior properties to hardwood pulps alone. In blends of kenaf and softwood kraft pulps, folding endurance and bursting resistance were greater than expected. Folding endurance was somewhat less than predicted for kenaf blends with hardwood-sulfite and groundwood pulps, but tear and opacity were improved.

Work was initiated on development of mechanical-type pulps for structural board from kenaf and a few related species. Chopping of the original materials to closely controlled sizes ranging from 1/2 to 1 inch, or dry shredding of original materials in a disk mill prior to cooking, appears to alleviate the earlier problem of nonuniformity associated with bimodal fiber systems in pulps from dicotyledons. Freeness requirements have been met by disk milling of materials cooked in weak neutral sulfite or soda solutions; however, the experimental pulps were still coarse and not in the acceptable range of characteristics in comparison with a reference wood pulp known to be suitable for resin-bonded fiber hardboard.

PUBLICATIONS AND PATENTS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Chemical Composition and Physical Properties

Bagby, M. O. 1961. Alkaline cleavage of a homolog of ricinoleic acid. J. Org. Chem. 26(11), pp. 4735-4737.

Bagby, M. O., Smith, C. R., Jr., Miwa, T. K., Lohmar, R. L., and Wolff, I. A. 1961. A unique fatty acid from *Limnanthes douglasii* seed oil: The C_{22} diene. J. Org. Chem. 26(4), pp. 1261-1265.

Daxenbichler, M. E., VanEtten, C. H., and Wolff, I. A. 1961. Identification of a new, naturally occurring, steam-volatile isothiocyanate from Lesquerella lasiocarpa seed. J. Org. Chem. 26(10), pp. 4168-4169.

Daxenbichler, M. E., VanEtten, C. H., Zobel, H., and Wolff, I. A. 1962. Isothiocyanates from enzymatic hydrolysis of Lesquerella seed meals. J. Am. Oil Chemists' Soc. 39(5), pp. 244-245.

Earle, F. R., Glass, C. A., Geisinger, G. C., Wolff, I. A., and Jones, Q.[1] ([1]USDA Crops Research Division, Beltsville, Md.). 1960. Search for new industrial oils. IV. J. Am. Oil Chemists' Soc. 37(9), pp. 440-447.

Jones, Q.,[1] and Wolff, I. A. ([1]USDA Crops Research Division, Beltsville, Md.). 1961. Using germ plasm for new products. In "Germ Plasm Resources." American Assoc. for the Advancement of Science, Washington, D. C., Publication No. 66, pp. 265-277.

Lohmar, R. L., Smith, C. R., Jr., and Wilson, T. L. 1960. Reaction of hydrogen bromide with conjugated dienols. J. Org. Chem. 25(11), pp. 2034-2035.

McGrew, C., and VanEtten, C. H. 1960. Volatile alcohols in dilute aqueous solutions by alkoxyl method. J. Assoc., Offic. Agr. Chemists 43(4), pp. 772-773.

Mikolajczak, K. L., Miwa, T. K., Earle, F. R., Wolff, I. A. 1961. Search for new industrial oils. V. Oils of Cruciferae. J. Am. Oil Chemists' Soc. 38(12), pp. 678-681.

Mikolajczak, K. L., Earle, F. R., and Wolff, I. A. 1962. Search for new industrial oils. VI. Seed oils of the genus Lesquerella. J. Am. Oil Chemists' Soc. 39(2), pp. 78-80.

Miller, R. W., VanEtten, C. H., and Wolff, I. A. 1962. Amino acid composition of Lesquerella seed meals. J. Am. Oil Chemists' Soc. 39(2), pp. 115-117.

Miwa, T. K., Mikolajczak, K. L., Earle, F. R., and Wolff, I. A. 1960. Gas chromatographic characterization of fatty acids. Identification constants for mono- and dicarboxylic methyl esters. Anal. Chem. 32(13), pp. 1739-1742.

Miwa, T. K., Smith, C. R., Jr., and Wilson, T. L. Dec. 13, 1960. Preparation of decanoic acid from Cuphea llavea seed. U. S. Patent 2,964,546.

Nelson, G. H., Nieschlag, H. J., Daxenbichler, M. E., Wolff, I. A., and Perdue, R. E., Jr.[1] ([1]USDA Crops Research Division, Beltsville, Md.). 1961. A search for new fiber crops. III. Laboratory-scale pulping studies. Tappi 44(5), pp. 319-325.

Nieschlag, H. J., Earle, F. R., Nelson, G. H., and Perdue, R. E., Jr.[1] ([1]USDA Crops Research Division, Beltsville, Md.). 1960. A search for new fiber crops. II. Analytical evaluations, continued. Tappi 43(12), pp. 993-998.

Nieschlag, H. J., Nelson, G. H., and Wolff, I. A. 1961. A search for new fiber crops. IV. Kenaf composition. Tappi 44(7), pp. 515-516.

Perdue, R. E., Jr.,[1] and Nieschlag, H. J. ([1]USDA Crops Research Division, Beltsville, Md.). 1961. Fiber dimensions of nonwoody plant materials. Tappi 44(11), pp. 776-784.

Smith, C. R., Jr., Bagby, M. O., Miwa, T. K., Lohmar, R. L., and Wolff, I. A. 1960. Unique fatty acids from Limnanthes douglasii seed oil: The C_{20}- and C_{22}-monoenes. J. Org. Chem. 25(10), pp. 1770-1774.

Smith, C. R., Jr., Burnett, M. C., Wilson, T. L., Lohmar, R. L., and Wolff, I. A. 1960. Differentiation of hydrogen bromide-reactive acids in seed oils. J. Am. Oil Chemists' Soc. 37(7), pp. 320-323.

Smith, C. R., Jr., Wilson, T. L., and Mikolajczak, K. L. 1961. Occurrence of malvalic, sterculic and dihydrosterculic acids together in seed oils. Chem. & Ind. 1961(8), pp. 256-258.

Smith, C. R., Jr., Wilson, T. L., Miwa, T. K., Zobel, H., Lohmar, R. L., and Wolff, I. A. 1961. Lesquerolic acid. A new hydroxy acid from Lesquerella seed oil. J. Org. Chem. 26(8), pp. 2903-2905.

Tookey, H. L., Lohmar, R. L., Wolff, I. A., and Jones, Q.[1] ([1]USDA Crops Research Division, Beltsville, Md.). 1962. New sources of seed mucilages. J. Agr. Food Chem. 10(2), pp. 131-133.

VanEtten, C. H., Miller, R. W., Earle, F. R., Wolff, I. A., and Jones, Q.[1] ([1]USDA Crops Research Division, Beltsville, Md.). 1961. Hydroxyproline content of seed meals and distribution of the amino acid in kernel, seed coat, and pericarp. J. Agr. Food Chem. 9(6), pp. 433-435.

VanEtten, C. H., Miller, R. W., Wolff, I. A., and Jones, Q.[1] ([1]USDA Crops Research Division, Beltsville, Md.). 1961. Amino acid composition of twenty-seven selected meals. J. Agr. Food Chem. 9(1), pp. 79-82.

Wilson, T. L., Miwa, T. K., and Smith, C. R., Jr. 1960. Cuphea llavea seed oil, a good source of capric acid. J. Am. Oil Chemists' Soc. 37(12), pp. 675-676.

Wilson, T. L., Smith, C. R., Jr., and Mikolajczak, K. L. 1961. Characterization of cyclopropenoid acids in selected seed oils. J. Am. Oil Chemists' Soc. 38(12), pp. 696-699.

Wilson, T. L., Smith, C. R., Jr., and Wolff, I. A. 1962. Lunaria seed oil--a rich source of C_{24} fatty acids. J. Am. Oil Chemists' Soc. 39(2), pp. 104-105.

Industrial Utilization of New Oilseeds

Hagemann, J. W., Mikolajczak, K. L., and Wolff, I. A. 1962. Purification of erucic acid by low-temperature crystallization. J. Am. Oil Chemists' Soc. 39(4), pp. 196-197.

Smith, C. R., Jr., Glass, C. A., and Wolff, I. A. Dec. 12, 1961. Method of preparing a drying oil and alkyl esters of all-trans-8,10,12-octadecatrienoic acid. U. S. Patent 3,013,037.

Smith, C. R., Jr., Glass, C. A., and Wolff, I. A. Mar. 27, 1962. Method of preparing a drying oil and intermediate therefor. U. S. Patent 3,027,388.

Industrial Utilization of New Gum and Fiber Plants

Clark, T. F., Atchison, J. E.,[1] Ernst, A. J., Gremler, E. R.,[2] and Wolff, I. A. ([1]Parsons and Whittemore Inc., New York, N. Y.; [2]Pandia Division, Black-Clawson Co., Hamilton, Ohio). 1960. Continuous pulping of wheat straw for corrugating media. Tappi 43(11), pp. 934-938.

Naffziger, T. R., Clark, T. F., and Wolff, I. A. 1961. Structural board from domestic timber bamboo--Phyllostachys bambusoides. Tappi 44(2), pp. 108-112.

Naffziger, T. R., Clark, T. F., and Wolff, I. A. 1961. Newsprint from domestic timber bamboo--Phyllostachys bambusoides. Tappi 44(7), pp. 472-475.

Tookey, H. L., Ernst, A. J., Lohmar, R. L., and Wolff, I. A. 1961. Evaluation of seed galactomannans from legumes as paper sizes. Tappi 44(12), pp. 910-912.

General

Senti, F. R., and Maclay, W. D. 1961. Age-old uses of seeds and some new ones. In "Yearbook of Agriculture 1961." U. S. Dept. Agr., pp. 27-36.

Wolff, I. A., and Jones, Q.[1] ([1]USDA Crops Research Division, Beltsville, Md.). 1960. Toward new chemurgic crops. Chemurgic Dig. 19(7), pp. 4-9.

Wolff, I. A., and Jones, Q.[1] ([1]USDA Crops Research Division, Beltsville, Md.). 1962. The search for new crops. In "Yearbook of Agriculture 1962." U. S. Dept. Agr., pp. 473-476.

COTTONSEED PROCESSING AND PRODUCTS
Southern Utilization Research and Development Div., ARS

Problem. Cottonseed products, currently approximately two billion pounds of oil and 2.5 million tons of meal derived from the annual domestic production of cottonseed, face increasing competition for markets. For its chief market, edible products, cottonseed oil must compete with other vegetable oils and animal fats. The nation's capacity for producing these oils and fats is so great that supplies can be expected to exceed both domestic and foreign demand for some time to come. Cottonseed meal, used chiefly as a protein supplement in feeding ruminant animals, faces serious competition from synthetic urea and other supplements. Improvements in the quality and utility of cottonseed oil are needed to retain present and open new markets for the currently large and possibly greater future production.

As an illustration, there is a discrimination in the markets against 25% to 50% of the current production of cottonseed oil due to the presence of reddish colors that are not removed by present commercial refining, bleaching and deodorizing methods. It is essential that information be developed on the chemistry of the pigments responsible for the off-colors, and that practical means be found to eliminate them and thus upgrade the oils, particularly for use in margarine and shortening. Additional information is needed urgently on the chemical and biochemical properties of cyclopropene fatty acids in cottonseed and means of converting them, if found necessary, into physiologically inert forms. New types of modified fats, such as polyester and polymeric fats, need to be developed from cottonseed oil for applications in the fields of edible and inedible coatings, waxes, resins, plasticizers, and lubricants. Cocoa butter-like fats and other confectionery fats derived from cottonseed oil could also provide new markets for large quantities of oil. Fundamental information is needed on hydrogenation to permit production of improved plastic fats. Other areas in which markets for cottonseed oil need to be developed through research include fat emulsions for intravenous feeding, edible emulsifiers, and fatty acid amides and derivatives for use as plasticizers, plastic foams and other industrial products. Improvement in the quality and nutritive value of cottonseed meal is needed so that it can better compete with other protein feed supplements. Additional information is needed on the physiologically active constituents of the meal responsible for egg abnormalities, swine mortalities and growth abnormalities of young animals that limit cottonseed meal's usefulness in poultry and swine rations. Processing methods must be devised for the commercial production of meals that can be fed to broilers, laying hens and swine, safely and without restriction. In order to lay the necessary groundwork for advances in cottonseed research on food, feed and industrial products and processing technology, additional fundamental information is also needed on the chemical composition and properties of cottonseed and of various cottonseed products.

USDA PROGRAM

The Department has a continuing long-term program involving organic chemists, physical chemists, analytical chemists, biochemists, chemical engineers, physicists, bacteriologists and microbiologists engaged in both basic and applied studies on cottonseed and its products to develop new or extended uses for these materials. Research to develop fundamental information on the chemical composition and properties of cottonseed products is conducted at New Orleans,

Louisiana, as a basis for efficient applied research in the fields of food, feed and industrial products from cottonseed. One phase of the work, research on cottonseed oil pigments, is supported in part by a Research Associateship maintained by the National Cottonseed Products Association at the Southern Regional Research Laboratory, New Orleans, Louisiana. Additional research on chemical composition and physical properties is carried out under contract at the University of Tennessee, Knoxville, Tennessee, on investigations of gossypol esters and mild oxidation products of gossypol and gossypol derivatives; and at the University of Illinois, Urbana, Illinois, on investigation of the chemical and physical properties of cyclopropene fatty acids in cottonseed. New and improved food products and processing technology are developed in research conducted at New Orleans, Louisiana. Research on confectionery fats is cooperative with the National Confectioners' Association who maintain a Fellowship at the Southern Regional Research Laboratory, New Orleans, Louisiana in partial support of the work, and evaluate promising research products. The Office of the Surgeon General supports research to develop fat emulsions for intravenous alimentation. This research is conducted in cooperation with the Louisiana State University Medical School, New Orleans, Louisiana, and several other research groups. A visiting research scientist sponsored by the government of Brazil assists with phases of the research on fats and oils, particularly that involving cyclopropene acids of cottonseed oil, at the Southern Regional Research Laboratory. Informal cooperation is maintained with industry in connection with the research on new and improved food products and processing technology. Research is carried out at New Orleans, Louisiana to develop new and improved feed products and processing technology for cottonseed. The National Cottonseed Products Association maintains a Fellowship at the Southern Regional Research Laboratory, New Orleans, Louisiana to partially support research on physiologically active constituents in cottonseed meals that adversely affect the utilization of the meal as a protein supplement in nonruminant feeding. The Pharmacology Laboratory at the Western Regional Research Laboratory, Albany, California, cooperates by conducting small-animal studies to determine the physiological and pharmacological effects of cyclopropene acids. Other animal tests in connection with the overall research program are conducted through the cooperation of nutritionists in State Agricultural Experiment Stations and the Animal Husbandry Research Division. In research directed toward providing a basis for the ultimate commercial production of cottonseed meals that can be fed to swine and poultry without restriction, as well as to ruminant animals, cooperation is maintained with the National Cottonseed Products Association, members of the cottonseed industry and nutritionists in public and commercial agencies. Because of the possible implications of this research to the utilization of cottonseed meals as protein sources in human nutrition, UNICEF sponsors two visiting foreign research scientists stationed at the Southern Regional Research Laboratory to assist with certain phases of the research. Research to develop new and improved industrial products and processing technology is conducted at New Orleans, Louisiana. Informal cooperation is maintained with industrial firms for the evaluation of promising research products for specific end uses. Additional research on new and improved industrial products is being carried out under contract at the University of Arizona, Tucson, Arizona, on the polymerization of reactive chemical intermediates derived from cottonseed oil and other agricultural materials to produce polymers having potential industrial utility.

Other research on chemical composition and physical properties is in progress under grants of P.L. 480 funds to the following foreign institutions: British Food Manufacturing Industries Research Association, Leatherhead, Surrey,

England, for fundamental studies of the fatty acid and glyceride composition of cottonseed oil and the crystallizing behavior of some of the major components (2.0 professional man-years); and University of Bombay, Bombay, India, for a study of the relationship of substituent fatty acid groups on the physical properties of diacid triglycerides of palmitic and stearic acids as a means of increasing the utilization of cottonseed oil for food and industrial purposes (3.3 professional man-years). Additional research to develop new and improved industrial products and processing technology is in progress under grants of P.L. 480 funds to the following foreign institutions: Institute for Research on Oils and Fats, Paris, France, for investigation of the preparation and properties of alkyl aryl ketones and their derivatives from vegetable oils for industrial applications (3.0 professional man-years); and University of Montevideo, Montevideo, Uruguay, for research on the preparation, characterization and evaluation of derivatives of gossypol for use as biologically active materials, ultraviolet absorbers and other products (3.4 professional man-years).

The Federal in-house scientific effort devoted to research in this area totals 40.8 professional man-years. Of this number 12.1 is devoted to chemical composition and physical properties, 16.1 to new and improved food products and processing technology, 10.1 to new and improved feed products and processing technology, and 2.5 to new and improved industrial products and processing technology. The contract research involves an additional 1.5 man-years, 0.8 being on chemical composition and physical properties and 0.7 on new and improved industrial products and processing technology. P.L. 480 research totals 11.7 man-years, of which 5.3 is on chemical composition and physical properties and 6.4 is on new and improved industrial products and processing technology.

The following lines of work were terminated during the year: (1) Investigations of the reactions of gossypol to aid the development of improved cottonseed meal and oil of enhanced value (under chemical composition and physical properties); (2) Development of new hydrogenation techniques for cottonseed and peanut oils to produce improved edible fat products and intermediates for industrial uses (under new and improved food products and processing technology).

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 0.3 professional man-years effort in this area, all under the subheading new and improved food products and processing technology. Chemical analysis and amino acid content determination have been made as a measure of nutritive value.

Industry and other organizations conduct a sizable amount of research in this area, the estimated annual expenditures being equivalent to approximately 75 professional man-years. Of this total about 12 man-years is on cottonseed processing research, 35 man-years on cottonseed oil processing research, and 28 man-years on developing new and improved cottonseed oil products.

Several engineering companies and processors are engaged in the development of new and improved processes and equipment for improving the efficiency of processing cottonseed, and for improving the feeding quality of the meal and the quality of the oil. The modern processing plants are the result of composite research effort and consist of elements of different manufacture, with

the trend being toward solvent extraction. The processors, through the National Cottonseed Products Association, support research through fellowships at the Southern Utilization Research and Development Division and grants to universities on improvement of cottonseed products, principally meal quality and oil color. Industry research is being implemented and stimulated through the results of basic and applied investigations at the Southern Utilization Research and Development Division.

Known research effort on processing of cottonseed oil is largely conducted by firms for their own use and is aimed at developing and improving methods for refining, bleaching, deodorizing, winterizing, and hydrogenating the oil. Engineering firms are developing improved processes and equipment. Processes receiving particular attention include solvent refining and bleaching, solvent winterization, deodorization, and continuous hydrogenation. Research toward finding better hydrogenation catalysts is underway. One large company is reviewing all of the conventional oil processing operations with a view of improving them. The National Cottonseed Products Association supports a Research Associateship at the Southern Utilization Research and Development Division on the identification and removal of the coloring substances in off-colored oils.

Research is directed by commercial firms toward developing new and improved products such as new plastic or semi-solid fats, cocoa butter-like and other confectionery fats derived in part from cottonseed oil, emulsifiers and other surface active agents, and new esters of various polyols and fatty acids. Glycerides containing cottonseed oil fatty acids and short-chain dibasic acids, developed at the Southern Utilization Research and Development Division, are now being investigated by one large manufacturer of fatty products. The National Confectioners Association sponsors a Fellowship at the Southern Utilization Research and Development Division and information developed relative to the making of new confectionery fats from cottonseed oil is disseminated by their Research Advisory Committee to oil processors and confectioners. Several companies are conducting relatively fundamental research, either in their own organizations or under contract, including research on glyceride configuration and physiological behavior of cottonseed oil and its products. Additional information on chemical composition and fundamental physical properties is desired but usually research in this area cannot be justified on the basis of immediate profit to the companies undertaking it. The industry looks to the Southern Utilization Research and Development Division, and similar organizations, for obtaining such basic information. Research for nonfood uses of cottonseed oil is being done at a low level, probably because cottonseed oil has historically been purchased and processed by a segment of the food industry which is not likely to search for nonfood uses. A plasticizer from cottonseed oil fatty acids, developed in the Southern Utilization Research and Development Division, is being evaluated commercially.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Chemical, Physical, and Biological Properties and Structural Factors of the Proteins. The composition, properties, structural factors and reactions of oilseed proteins and associated materials are being investigated as a basis for development of new concepts and possibly new uses for oilseed proteins, including cottonseed protein. Major areas of recent research have included

studies of seed globulins, of their subcellular distribution, and of a specific group of seed proteins, the lipases. Since peanuts were found to be an especially suitable experimental material and employed for much of this fundamental research on seed proteins, the report of progress in the research is given in Area No. 7, "Peanuts Processing and Products."

2. Chemical and Physical Properties of Pigments and Minor Constituents Including Cyclopropene Fatty Acids. Additional information was developed concerning the problem pigments of off-color cottonseed oils as a possible basis for improving the color and quality of these type oils. Two major pigment fractions from a model system (refined and bleached cottonseed oil anaerobically reacted with gossypol) were resolved chromatographically through the use of powdered cellulose and silicic acid columns. Each of these fractions was further separated into two components by means of countercurrent distribution. Purification and characterization of the four components is in progress. One has yielded a homogeneous, major fraction in which there is evidence for the presence of esters. Indications are that an ester interchange reaction occurs and the problem pigments may be partial esters of gossypol or anhydrogossypol A Research Associate of the National Cottonseed Products Association assists with the research. (S4 1-96).

In continued contract research at the University of Tennessee on the chemistry and reactions of gossypol, (1) twenty new gossypol anils were prepared, (2) desapogossypol was synthesized and converted to several acetate derivatives, (3) apogossypol hexallyl ether was made and studied, (4) 1, 4-binaphthoquinones derived from gossypol were found to undergo epoxidation at the 2, 3 positions, (5) three crystalline oxidation products of gossypol were isolated, (6) an unusual mono-Diels-Alder adduct between anhydrogossypol and cyclopentadiene was discovered, and (7) evidence was obtained for an interchange reaction between a gossypol anil and an amine. A variety of biological activity tests on gossypol derivatives failed to indicate any chemotherapeutic use for gossypol or its derivatives. The contract project has been terminated, and new contract research initiated at the University of Tennessee involving investigations of gossypol esters and of mild oxidation products of gossypol and gossypol derivatives to develop information needed to aid the production of cottonseed meals and oils of the highest quality (S4 1-73(C); S4 1-103(C)).

Several approaches have been found which look promising for the development of quantitative analytical methods for determination of cyclopropene acids in cottonseed products. Among the promising methods under further development are the following: (1) a modification of the conventional qualitative Halphen color test method, (2) a modified hydrobromic acid titration method, (3) a procedure based on chlorine analysis after treatment with aqueous hydrochloric acid, and (4) a method involving infrared absorption measurements on the hydrochloric acid-treated materials. These methods are being examined as to precision, range of application, and influence of interfering substances. Recently initiated contract research at the University of Illinois to investigate chemical and physical properties of cyclopropene fatty acids in cottonseed should aid in the development of such quantitative methods of analysis, and in improving cottonseed meal and oil. (SG-0-1; S4 1-104(C)).

3. Chemical and Physical Properties of the Oil and Fatty Acids. Evidence has been obtained that the chemical and physical properties of cottonseed oils bleached with normal activated alumina are almost identical with those for oils bleached with the conventionally used Fuller's earth. In the laboratory

experiments it was found that alumina bleaching does not impair oil stability or induce significant amounts of isomerization in the oil. These are important findings for possible commercial use of alumina for bleaching off-color cottonseed oils. The spent alumina can be reactivated by simple incineration at 500°-550°C., and reused repeatedly without loss of its effectiveness as a bleaching agent and with little loss of alumina. It was also observed that if the alumina is first treated with aqueous sulfurous acid, the capacity of the alumina to remove green pigments, as well as the problem pigments of off-color oils, is enhanced and the Halphen test (cyclopropene acids) is negative. No adverse effect on properties of the bleached oils has been observed to date. (S4 1-96).

New systematic solubility data on long-chain fatty acids and their derivatives in various industrial solvents were obtained to develop correlation methods and information fundamental to research on industrial utilization of fatty acids from cottonseed oil and other vegetable oils. The pure cyclohexylamine salts of stearic, palmitic, myristic, and lauric acids were prepared and solubility curves for the salts in benzene were obtained. Solubility curves were also determined for the cyclohexylamine salts of capric and heptadecanoic acids in benzene and in acetone to complete the series in these two solvents. With the exception of the heptadecanoic salt, as anticipated, the results show good agreement when correlated by means of isotherm and isopleth correlation graphs. The existence of two polymorphic forms of elaidic acid was confirmed by obtaining the solubility curves of both modifications in methanol down to -10°C. It is planned to investigate the solubilities of the cyclohexylamine salts of the various fatty acids in methanol. The data will be correlated to provide a basis for prediction of solubilities. (S4 1-88).

In P.L. 480 research at the British Food Manufacturing Industries Research Association, studies are in progress on the fatty acid and glyceride composition of cottonseed oil and the crystallizing behavior of some of the major components. Cottonseed oils produced from seed grown under various environmental conditions may differ appreciably in the amounts of the component fatty materials they contain; this, in turn, affects the yields obtained and the characteristics of the finished product when these oils are processed to obtain salad oil. The crystallizing behavior and the influence of oil composition of a number of cottonseed oils of different environmental origins are being studied under various processing conditions. The study will provide data useful in the selection and processing of cottonseed oils for the commercial production of improved salad oils in optimum yields. (UR-E29-(40)-26).

B. New and Improved Food Products and Processing Technology

1. New Edible Oil Products Including Confectionery Fats, Food Coatings and Other Specialty Products. Further research was done on the production of a cocoa butter-like fat, principally to devise suitable procedures to remove the small amounts of high-melting, trisaturated glycerides whose presence in earlier batches of the product was deemed undesirable. It was found that the trisaturated glycerides may be conveniently removed from cocoa butter-like fats by special tempering procedures and then filtering or by crystallization from a 1:1 solution of the fats in petroleum ether. Dilatometric examination of the purified, deodorized fats revealed that a well-tempered sample contained only 0.7% liquid oil at 15°C. and 96.3% at 35°C., which is very desirable.

Research was conducted on the molding characteristics of cocoa butter to develop fundamental data for improving the demolding performance of synthetic cocoa butter-like fats. High solids content at time of molding resulted in poor contraction. Further, it was established that to obtain proper contraction on solidification of cocoa butter, seeds of the highest melting polymorphs should be present and solidification and tempering should be carried out between 14° and 16° C. In the course of the work, a procedure was developed for determining the maximum linear contraction of cocoa butter and cocoa butter-like fats on solidification.

Films of cocoa butter were produced which have much improved resistance to permeability to water vapor than previously prepared films. A synthetic cocoa butter-like fat, however, gave films about five times as permeable as the best cocoa butter films.

In the course of laboratory work on the fundamental properties of cocoa butter and other confectionery fats, it was discovered that cocoa butter, the Southern Division's cocoa butter-like fat, and some other fats can be transformed directly into the stable crystal form by extrusion of the unstable crystal forms through small orifices under high pressure. The transformation has been found to be due to mechanical working under these conditions and not an effect of high pressure alone. This new process could result in a simplified and more direct process of manufacturing chocolate in that the process could be truly continuous and the use of tempering kettles could be eliminated. Good progress has also been made in determination of dilatometric and other physical properties of the individual glyceride components of the confectionery fats.

A promising new approach to making cocoa butter-like fats and other special fats has been discovered. It involves direct esterification of diglycerides (of palmitic and stearic acids, for example) with oleic acid in such a manner that interesterification doesn't occur, although some isomerization of the diglycerides occurs prior to the esterification. Cocoa butter-like fat products having good melting characteristics were obtained in the laboratory in high yield by this procedure which will be investigated further. The research on confectionery fats is supported in part through a fellowship sponsored by the National Confectioners' Association. (S4 1-91).

In continued research on new polyester products from cottonseed oil, work was completed on a series of fatty acid esters of amylose containing oleic, linoleic and the even-numbered saturated fatty acids C_2 through C_{18}. The degree of acylation was found to be inversely proportional to the chain length of the acyl group. Intrinsic viscosities decreased as the chain length increased, a reflection of the changing nature of the products rather than the degree of polymerization of the amylose. The effects of chain length and degree of unsaturation were determined for such properties as softening point, hardness index, density, tensile strength, percent elongation, and permeability to water vapor. Results indicate that it is possible to tailor-make film-forming polyesters with specific properties by varying the length of substituted acyl group and the extent of unsaturation.

Recent research has been directed toward devising new and more economical methods of preparing glycerides and dibasic acid-containing polyester fats. Some preliminary experiments indicated that only one-half of a dibasic acid can be esterified effectively with a diglyceride. It should be possible to esterify the half-ester with hydroxyl groups as in mono- and diglycerides, fatty alcohols, or phenols. Other investigations have been concerned with the

preparation of specific diglycerides by controlled esterification. Preliminary experiments with 1-monostearin and oleic acid indicate that simple esterification predominates, although there is some ester interchange, and the process should be valuable for preparing diglycerides. Further work is underway to obtain a more complete understanding of the mechanism of the esterification.

In another phase of the research, involving investigation of the fungistatic effect of fatty acids and fats derived from cottonseed oil, compounds containing caproic acid were synthesized and tested for fungistasis by a recently developed method for quantitative estimation of fungistasis by fats. Tricaproin has been found to have some fungistatic effect on certain microorganisms. (S4 1-90).

Research supported by the Office of the Surgeon General was continued on the development of emulsifiable oils and fats for use in fat emulsions for intravenous alimentation. An improved fat emulsion (675) was developed and used successfully for infusions on dogs. When close analytical control of the purity of the emulsifying system is maintained, the test animals have shown no abnormal effects, such as development of anemia or pulmonary effusions, as observed with previous emulsions. The principal emulsifying agent in this emulsion is a stearate ester of polyethylene glycol, the latter a mixture of polymers of several molecular weights. Analytical control methods have been set up for the emulsifiers so that successive batches of materials will meet critical specifications.

Recently, a more homogeneous and improved primary emulsifying agent has been synthesized in the laboratory by esterifying purified palmitic acid with a molecularly distilled fraction of polyethylene glycol. The new emulsifier has also been prepared by a commercial firm, and following purification has proven comparable to the laboratory preparation. The use of this primary emulsifier (polyethylene glycol palmitate) in conjunction with a non-acetylated secondary emulsifier in a fat emulsion has given significant improvements in the physiologic response of dogs administered the emulsion. The physiologic advantages are obtained with no sacrifice of desirable physical properties of the emulsion. The emulsion (695) has now been prepared commercially, extensively evaluated on animals, and is undergoing clinical evaluation.

Synthetic triglycerides are being prepared for use in a study of the cause and nature of liver pigmentation resulting from prolonged administration of all cottonseed oil emulsions irrespective of emulsifier system. Methods of modifying cottonseed oil to eliminate its response to the Halphen color test are also being investigated in connection with use of the oil as the lipid source of emulsions. (SG-0-1).

2. Processing Technology Related to Improved Oil Products, Including Modifying or Eliminating Cyclopropene Acids in Cottonseed Oil. Engineering studies were initiated to develop a commercially feasible process for preparing cocoa butter-like fats based on chemical laboratory research. Approximately 100 pounds of crude cocoa butter-like fat (No. 5) were produced in the pilot plant. An increase in yield of about 25% was obtained, presumably due to a new method of adding the catalyst. The product was further purified, yielding 77 pounds of a cocoa butter-like fat exhibiting improved melting behavior due to removal of small amounts of saturated fats during the purification. Confectioners are evaluating the fat. Revised costs for producing cocoa butter-like fats from cottonseed oil have been prepared, reflecting the

effect of recent changes in process development to improve product quality. Future work will place emphasis on studies of the effect of short crystallization time, an important consideration in the commercialization of a continuous process for producing cocoa butter-like fat. (S4 1-101).

Development work on bleaching off-color cottonseed oils with activated alumina is in progress to devise a commercially practical bleaching process based on the use of this highly active adsorbent. Laboratory scale alumina bleaching tests indicated that combining alumina bleaching with deodorization was not as effective in reducing oil color as bleaching alone. Batch type bench scale equipment to permit rapid evaluation of process variables and provide necessary process design data was designed and fabricated. Preliminary tests with the equipment showed it would be necessary to find a commercial source of an alumina having the correct particle size distribution for rapid filtration from the oil as well as good bleaching power; and a method of removing green color from the oil would be needed. A subsequent extensive series of tests with a variety of aluminas has shown that none of the commercial aluminas received up to the present time have the required properties of maximum bleaching activity and desired particle size. The preparation of such aluminas in commercial quantities may present special problems. The use of small amounts of carbon (0.1% of oil weight) mixed with alumina in pilot-plant runs has proved to be a solution to the problem of reducing green color. Results with five commercial oils show that rerefining followed by natural earth bleaching yields bleached oils of appreciably lighter colors than can be obtained by bleaching with four percent of alumina. Oil losses by rerefining followed by earth bleaching were slightly lower than the losses by alumina bleaching. Preliminary estimates based on available pilot-plant data indicate that the cost of bleaching off-color cottonseed oils with alumina should be comparable to the cost of present commercial procedures (rerefining, followed by earth bleaching) for processing these oils. The research is now being concentrated on improving filtration rates either by preparing aluminas of suitable particle size or employing filter aids, to make the process commercially feasible. (S4 1-92).

Studies of the hydrogenation process for modification of vegetable oils are being made to develop new hydrogenation techniques for cottonseed and peanut oils that will enable the production of new and improved edible fat products. Further work on hydrogenation of methyl esters of fatty acids using the Adkin's No. 5 nickel catalyst showed that it was not possible to reproduce with any precision the activity of this catalyst for the methyl esters. Factors such as the amount of aluminum present in the catalyst, and the support material for the catalyst, may be responsible.

The minimum concentration of palladium-on-carbon catalyst which would not cause an appreciable decrease in the hydrogenation rate of a triglyceride oil in solvent was determined, and the effect of temperature in the range from 30° to 55°C. was studied. In other experiments with this catalyst it was established that without use of solvent, neither the least practical amount of catalyst nor very low hydrogenation temperatures were effective in reducing the amount of trans isomers formed to an acceptable level. However, the use of solvent resulted in a significant reduction of the trans isomer content of the product.

In recent research the important discovery was made that position of the unsaturated acyl groups on the glycerol molecule does not influence

hydrogenation rate. A method has also been developed for preparing nickel catalysts having greater activity and stability, capable of producing improved hydrogenated fats with lower trans isomer content.

Initial experiments on the use of hydrogenation in modifying or eliminating the physiologically active constituents, cyclopropene fatty acids, in cottonseed oil indicate that these acids can be removed by hydrogenation under conditions which do not hydrogenate the linoleoyl groups or oleoyl groups or produce positional isomers of these groups. This promising approach will be investigated further. (S4 1-84; S4 1-102).

C. New and Improved Feed Products and Processing Technology

1. Basic Research to Improve Nutritive Value of Cottonseed Meal for Laying Hens and Swine, Including Investigations of Cyclopropene Acids in the Meal. Much of the confusion in the literature relating to the discolorations in stored shell eggs from cottonseed meal-fed hens has been cleared up through the discovery that the chromogen in the yolk is a pH indicator, and that the brown color develops in the yolk only when the yolk pH is abnormally high. The physiologically active gossypol derivatives in cottonseed meal responsible for the brown chromogen in the yolks are tightly bound in the meal and are not removed by any one of several solvents. The Halphen-positive fatty acid of cottonseed glycerides was isolated and identified as 2-octyl-1-cyclopropene-1-heptanoic (malvalic) acid. The presence of this acid in cottonseed meals fed to laying hens accentuates the yolk color problem because the effect of Halphen acid on the permeability of the vitellin membrane fosters an abnormally rapid increase in yolk pH while the eggs are in cold storage. A Fellow of the National Cottonseed Products Association assisted with this research.

Feeding tests have confirmed the high nutritive value of hexane-acetone-water extracted cottonseed meals and also confirmed the previous conclusion that total gossypol and lysine, but not free gossypol, are of paramount importance in determining the nutritive quality of cottonseed meal. In other research a heat labile antinutrition factor, extractable with hexane-acetone-water solvent mixture, has been found in cottonseed. This suggests that the nutritive quality of cottonseed meal may be further improved.

It has also been found that cottonseed products high in protein and low in crude fiber can be obtained through air separation of ground cottonseed meal. Preliminary analyses indicate that the protein-rich fraction from the air separator is also richer in lysine. Use of this technique offers a possible approach for producing meals of high protein and low fiber content for broiler and swine feeding.

The high-lysine (5.2%) protein fraction from glandless cottonseed (approximately 25% of the total protein) is glyco-protein; color reactions indicate the presence of amino sugars. The protein fraction is rich in sulfur and poor in phosphorus. Exploratory experiments to determine the importance of processing on the several amino acids in cottonseed meals show that epsilon free amino lysine is the most labile amino acid. Studies with dinitrofluorobenzene treated meals have formed the basis for more rapid and more reliable methods for available lysine assay in oilseed meals. Recent investigations of ion-exchange chromatography of amino acids in hydrolyzates of cottonseed proteins prior to and following dinitrofluorobenzene treatment

of the cottonseed meal have shown that this method can be used for quantitative determination of available lysine. A UNICEF-sponsored research scientist participated in this research.

Basic studies are in progress on the fractionation of the alcohol-salt soluble cottonseed proteins to determine the nature of the growth stimulating factor that appears to be present in cottonseed. Protein fractions have been isolated which are rich in the basic amino acids, lysine and arginine; high in the acidic amino acid, glutamic acid; and exceptionally high in the sulfur amino acids, cystine/cysteine and methionine, as compared with the whole cottonseed meal. Accompanying this is a sharp decrease in the neutral amino acid content and a complete inversion of the tyrosine/phenylalanine ratio. Preliminary evidence indicates that the proteins from glandless cottonseed may be significantly richer in threonine and valine than those from glanded seed.

The usefulness of Tetrahymena pyriformis W. is being explored in a continued effort to find a rapid and economical means of evaluating nutritive quality of cottonseed meals.

Basic studies of the gossypol-amine reaction are yielding information which may point the way to a reversal of the gossypol-lysine reaction in meals, thereby improving their nutritive quality.

Cottonseed oils bleached with sulfurous acid-treated alumina to give a negative Halphen test, as well as conventional oils, are being used in tests on chicks and laying hens to obtain data on the physiological effects of malvalic acid present in cottonseed. The results will also be of importance from the standpoint of use of alumina for bleaching cottonseed oils. (S4 1-95; S4 1-97).

2. Processing Technology Related to Improved Meals Including Removal or Inactivation of Cyclopropene Acids. Based on laboratory findings which indicated that processing cottonseed with a solvent mixture of hexane-acetone-water could be employed to produce improved cottonseed meals suitable for swine and poultry feed, engineering studies were initiated to develop such a process suitable for use on a commercial scale. Two approaches showing considerable promise have been investigated on a pilot-plant scale.

In one of these approaches the development work is directed toward adaptation of existing commercial basket extraction plants to the mixed solvent process with the minimum modification of, or use of, additional equipment. A modified process is being sought that provides optimum combination of extraction efficiency for oil and gossypol, with satisfactory plant operation in the various steps of extraction, meal desolventizing, oil desolventizing, mill-site oil or miscella refining, solvent rectification, reconstitution and continuous regulation of solvent composition. Plant capacity, solvent losses, loss of product weight due to solution of non-lipids in the mixed solvent, oil quality and over all costs are also factors being considered in the choice of mixed solvent composition and process features. In pilot-plant runs using an 8-cell countercurrent basket extractor, the guide lines for total gossypol (0.30%) and epsilon-amino-free lysine (4.0 grams per 16 grams of nitrogen) were consistently met and for free gossypol (0.03%) and lipids (0.5%) were approached at extraction times of 120 minutes and ambient

temperatures. However, extraction rates for oil and gossypol will have to be improved to achieve guide line values in about 40 minutes corresponding to commercial practice. A UNICEF-sponsored research scientist assists with this research.

The second approach has involved use of a 10-stage countercurrent continuous extraction with a vibrating screen separator (Sweco). Processing experiments have shown this type of extraction using hexane-acetone-water solvent mixture to be practicable---fines and screenings can be handled continuously by recirculating them at suitable points in the extraction cycle. Pilot-plant scale recovery and refining of oils from mixed solvent-extraction indicated the procedure to be practical on a larger scale. Meals and oils of superior quality were obtained.

UNICEF is conducting comprehensive nutritional tests on some mixed solvent-produced cottonseed meals. Preliminary reports indicate protein efficiency ratios comparable to those obtained for toasted soy products. (S4 1-94; S4 1-95).

D. New and Improved Industrial Products and Processing Technology

1. Basic Research to Develop New Reactions and Products Suitable for Industrial Use. Long-chain fatty amides and derivatives are being prepared, characterized, and evaluated as plasticizers, stabilizers, polyurethane foams, and for other industrial uses. The selectively hydrogenated cottonseed oil fatty acid morpholide developed in earlier research has been successfully prepared in quantity in the pilot plant. This plasticizer for vinyl plastics and cellulose triacetate is undergoing evaluation tests by industrial firms.

The morpholide of selectively hydrogenated cottonseed acids has been found to be an effective compatibilizer for incompatible fatty acid type plasticizers. It is also an effective compatibilizer for hydrocarbon type extenders in vinyl chloride and vinyl chloride copolymer resins. Cost aspects of the morpholide are thereby improved; and the extenders also give the beneficial effect of reducing soapy water extractability. By condensing partially epoxidized cottonseed fatty acids with morpholine, an efficient plasticizer and particularly good stabilizer for vinyl chloride has been made.

In other work it was established that the morpholide of parsley seed fatty acids is a highly efficient compatible plasticizer for vinyl chloride; and indications are that the morpholide of dimer linoleic acid might be a satisfactory vinyl plasticizer in such uses as floor tiling. Preliminary experiments indicate that dimerization may be preferable to hydrogenation in the preparation of cottonseed morpholide plasticizers.

Two crystalline forms of elaidic acid (freezing points, 43.7° and 44.8°C.) have been isolated in the course of the research. This is the first trans-alkenoic acid known to occur in two polymorphic forms. Binary freezing point diagrams for the systems oleic acid-petroselinic acid, oleic acid-petroselaidic acid, oleic acid-elaidic acid, elaidic acid-petroselinic acid, and elaidic acid-petroselaidic acid were constructed and all found to be of the simple eutectic type.

Additional N,N-disubstituted long-chain fatty amides have been prepared, characterized, and evaluated as polyvinyl chloride plasticizers.

N,N-bis(2-acetoxyethyl)oleamide and N-oleoylpiperidine compare favorably with other acceptable plasticizers, giving brittle points of -44° and -47°C. and volatility losses of 0.80 and 1.17%, respectively, as compared to -31°C. and 1.50% for dioctyl phthalate and -55°C. and 6.00% for the more expensive dioctyladipate. A simplified synthesis of the bis compound has been found which should reduce cost to a realistic competitive level. Some fifty long-chain amides and substituted amides have been submitted to screening for antibacterial activity. A number of them show exceptional promise as anti-mycotic agents, being effective against a broad spectrum of organisms. The research effort will continue on other fatty amide derivatives, particularly substituted piperidines. (S4 1-99).

Contract research at the University of Arizona is directed toward development of new industrial products by polymerization of reactive chemical intermediates derived from selected agricultural materials, including cottonseed and other vegetable oils. Emphasis is on polymers for use as elastomers, plastics, thickening agents, and protective coatings. Copolymers prepared by copolymerizing vinyl chloride with vinyl 12-ketostearate, with vinyl 4-ketostearate, and with vinyl 9(10)-ketostearate have been milled into plastic form to evaluate the effect of the keto group on internal plasticization. The keto compounds were found to have no advantage in this respect over vinyl stearate. The polymerization of vinyl esters of other fatty acid derivatives has been studied, including the preparation of copolymers of vinyl chloride with vinyl tetrachlorostearate and with vinyl dichlorostearate, and homopolymers of the latter compound and other monomers. Evaluation of the properties of the polymers is in progress. (S4 1-89(C)).

P.L. 480 research at the Institute for Research on Oils and Fats is concerned with the preparation and properties of alkyl aryl ketones and their derivatives from vegetable oils for industrial applications. This research has produced chemical derivatives of the alkyl aryl ketone type that have potential utility in such industrial products as fungicides, lubricants, plasticizers, and surface-active agents. (UR-E9-(00)-29).

The preparation, characterization, and evaluation of derivatives of gossypol having potential industrial utility is in progress under P.L. 480 research at the University of Montevideo. Since gossypol is a very reactive polyfunctional polyphenolic pigment which can be obtained in good yield from by-products of the refining of cottonseed oil, it is currently being explored as an intermediate in the preparation of compounds useful in pharmaceuticals, insecticides, fungicides, ultraviolet absorbing or screening agents, and similar materials. (UR-S9-(40)-2).

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Chemical Composition and Physical Properties

Bailey, August V., Magne, Frank C., Pittman, Robert A. and Skau, Evald L. 1961. Effect of extraction temperature and refining on the halphen-test response of cottonseed oil. J. Am. Oil Chemists' Soc. 38, pp. 505-506.

Berardi, Leah C. and Frampton, Vernon L. 1961. Spontaneous conversion of gossypol to anhydrogossypol J. Am. Oil Chemists' Soc. 38, pp. 51-52.

Frampton, Vernon L., Pons, Walter A., Jr. (Southern Utilization Research and Development Division), and Kerr, Thomas (Crops Research Division, Beltsville, Maryland). 1960. A comparison of chemical properties of seeds of gossypium

species. Econ. Botany 14, pp. 197-199.
Frampton, Vernon L. 1961. Composition and quality characteristics of glandless cottonseed. Cotton Improvement Conf. Proc. 13, pp. 73-80. Published by National Cotton Council of America, Memphis, Tenn.
Kuck, J. C., Pons, W. A., Jr., and Frampton, V. L. 1962. Reactivation of alumina used in bleaching of off-colored cottonseed oils. J. Am. Oil Chemists' Soc. 39, pp. 84-86.
Moore, Anna T., and Rollins, Mary L. 1961. New information on the morphology of the gossypol pigment gland of cottonseed. J. Am. Oil Chemists' Soc. 38, pp. 156-160.
O'Connor, Robert T. 1961. Near-infrared absorption, spectroscopy - A new tool for lipid analysis. J. Am. Oil Chemists' Soc. 38, pp. 641-648.
O'Connor, Robert T. 1961. Recent progress in the applications of infrared absorption spectroscopy to lipid chemistry. J. Am. Oil Chemists' Soc. 38, pp. 648-659.
Pons, Walter A., Jr., Kuck, James C., and Frampton, Vernon L. 1960. Color index for cottonseed oils. J. Am. Oil Chemists' Soc. 37, pp. 671-673.
Pons, Walter A., Jr., Kuck, James C., and Frampton, Vernon L. 1961. Bleaching of off-colored cottonseed oils. J. Am. Oil Chemists' Soc. 38, pp. 104-107.
Pons, Walter A., Jr., and Kuck, James C. May 22, 1962. Process for bleaching off-color cottonseed oils. U. S. Patent No. 3,036,102.
Shirley, David A., and Alley, Peggy W. (University of Tennessee). 1960. Some new reactions and reaction products of apogossypol and desapogossypol. J. Org. Chem. 25, pp. 1391-1394.
Thaung, U. Kyaw (Trainee, Institute of International Education, UNESCO), Gros, Audrey, and Feuge, R. O. 1961. Characterization of oils from low-gland and glandless cottonseed. J. Am. Oil Chemists' Soc. 38, pp. 220-224.
Verberg, Gerald, McCall, Elizabeth R., O'Connor, Robert T., and Dollear, F. G. 1961. Cottonseed oil pigments. Fractionation by means of molecular sieves, countercurrent distribution, and low-temperature crystallization. J. Am. Oil Chemists' Soc. 38, pp. 33-39.

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Benerito, Ruth R., Talluto, Katherine F., White, J. L. and Singleton, W. S. 1960. Comparative effects of oral and intravenous administration of fat emulsion on sera fractions of dogs. Metabolism, Clin. and Exptl. 9, pp. 769-777. 1/
Cousins, E. R. and Feuge, R. O. 1960. Hydrogenation of methyl oleate in solvents. J. Am. Oil Chemists' Soc. 37, pp. 435-438.
Decossas, K. M., Koltun, S. P., Spadaro, J. J., Feuge, R. O., Pollard, E. F. and Patton, E. L. 1962. Cocoa butter-like fat from cottonseed oil: Preliminary cost study. J. Am. Oil Chemists' Soc. 38, pp. 146-150.
Feuge, R. O. 1960. Production of specialty edible fats. J. Am. Oil Chemists' Soc. 37, pp. 527-532.
Feuge, R. O. 1960. Find molding difficulty in test coatings using cocoa butter-like fat. Candy Ind. & Confectioners J. 115(4), pp. 11-13, 30.
Feuge, R. O. 1961. Cocoa butter-like sample. I. Coating with fat No. 5 has better temper. --- II. Fat No. 5 shows low bloom tendencies. Candy Ind. & Confectioners J. 117(1), pp. 34-35; (2) pp. 7-8.

1/ Publication resulting from research supported by funds transferred from the Office of the Surgeon General

Gros, Audrey T. and Feuge, R. O. 1962. Properties of the fatty acid esters of amylose. J. Am. Oil Chemists' Soc. 39, pp. 19-24.

Landmann, Werner, Feuge, R. O. and Lovegren, N. V. 1960. Melting and dilatometric behavior of 2-oleopalmitostearin and 2-oleodistearin. J. Am. Oil Chemists' Soc. 37, pp. 638-643.

Landmann, Werner, Lovegren, N. V. and Feuge, R. O. 1961. Confectionery fats. II. Characterization of products prepared by interesterification and fractionation. J. Am. Oil Chemists' Soc. 38, 466-469.

Landmann, W., Lovegren, N. V. and Feuge, R. O. 1961. Dilatometric properties of some glycerides of confectionery fats. J. Am. Oil Chemists' Soc. 38, pp. 681-685.

Mann, G. E., Brown, M. L., DiTrapani, L. L. and Singleton, W. S. 1961. Interactions in fat emulsion---protein systems. Metabolism 10, pp. 859-868. 1/

Shull, Rosemary L., Gayle, Louis A., Coleman, Richard D., Alfin-Slater, Roslyn B. (University of Southern California), Gros, Audrey T. and Feuge, R. O. 1961. Metabolic studies of glyceride esters of adipic acid. J. Am. Oil Chemists' Soc. 38, pp. 84-86.

Singleton, W. S., Benerito, Ruth R., Talluto, Katherine F., Brown, Mona L., DiTrapani, Lara Lee and White, J. L. 1960. Effects of prolonged intravenous administration of fat emulsions on serum proteins of dogs. Metabolism, Clin. and Exptl. 9, pp. 956-965. 1/

Singleton, W. S., White, J. L., DiTrapani, L. L. and Brown, M. L. 1962. An emulsifier system for experimental intravenous fat emulsions. J. Am. Oil Chemists' Soc. 39, pp. 260-263. 1/

Spadaro, J. J., Lovegren, N. V., Feuge, R. O. and Patton, E. L. 1961. Confectionery fats. I. Preparation by interesterification and fractionation on pilot-plant scale. J. Am. Oil Chemists' Soc. 38, pp. 461-465.

New and Improved Feed Products and Processing Technology

Anon. 1960. Proceedings of the ninth cottonseed processing clinic, February 15-16, New Orleans, La. (Sponsored jointly by Southern Utilization Research and Development Division, ARS, U. S. Department of Agriculture, New Orleans, La., and Mississippi Valley Oilseed Processors Association, Inc.) 55 pp. (Processed).

Anon. 1961. Proceedings of the tenth cottonseed processing clinic. U. S. Dept. Agr. ARS 72-25, 61 pp.

Anon. 1962. Proceedings of a conference on cottonseed protein for animal and man. U. S. Dept. Agr. ARS 72-24, 77 pp. (Compiled and edited by Thomas H. Swan and Aaron M. Altschul).

D'Aquin, E. L., Graci, A. V., Jr., Vix, H. L. E. and Gastrock, E. A. 1961. Improved extraction efficiency by double-soak, filtration-extraction process. J. Am. Oil Chemists' Soc. 38, pp. 258-261.

Decossas, K. M., Koltun, S. P., Eaves, P. H., Spadaro, J. J., Pollard, E. F. and Patton, E. L. 1960. Methyl esters directly from acidulated cottonseed soapstock: Preliminary cost study. J. Am. Oil Chemists' Soc. 37, pp. 574-576.

Eaves, Paul H. and Spadaro, James J. November 28, 1961. Process for the methylation of vegetable oil soapstocks. U. S. Patent No. 3,010,977.

1/ Publication resulting from research supported by funds transferred from the Office of the Surgeon General

Frampton, V. L. 1961. Azeotrope extraction of cottonseed. Oil Mill Gaz. 66(2), pp. 33-39.

Frampton, Vernon L., Carter, Fairie Lyn, Piccolo, Biagio (Southern Utilization Research and Development Division), and Heywang, B. W. (Southwest Poultry Experiment Station, Glendale, Arizona). 1962. Cottonseed constituents and discolorations in stored shell eggs. J. Agr. Food Chem. 10, pp. 46-48.

Frampton, Vernon L. and Piccolo, Biagio. 1961. Cottonseed meal in poultry feed. Collaborative study of the AGU method of grading cottonseed meals for laying rations. J. Agr. Food Chem. 9, pp. 129-131.

Frampton, Vernon L. and Piccolo, Biagio (Southern Utilization Research and Development Division), and Heywang, Burt (Southwest Poultry Experiment Station, Glendale, Arizona). 1961. Cottonseed meal in poultry feed. Discolorations in stored shell eggs produced by hens fed cottonseed meal. J. Agr. Food Chem. 9, pp. 59-63.

Holzenthal, Leo. December 13, 1960. Cottonseed cleaner. U. S. Patent No. 2,964,180.

Holzenthal, Leo L., Gastrock, E. A. and Gentry, W. T., Jr. 1961. Evaluation of a prototype unit to separate foreign material from cottonseed utilizing inclined plane moving surfaces. Oil Mill Gaz. 66(3), pp. 9-14.

Holzenthal, Leo L., Molaison, L. J., Gentry, W. T., Jr., Gastrock, E. A. and Patton, E. L. 1961. The ARS 8' x 10' cottonseed cleaning-belt unit - improved operation with a beater-type opener-feeder. Oil Mill Gaz. 66(6), pp. 5, 7-9.

King, William H. and Frampton, Vernon L. August 23, 1960. Production of cottonseed meal of improved quality. U. S. Patent No. 2,950,198.

King, W. H. and Frampton, V. L. 1961. Properties of oil extracted from cottonseed with acetone-hexane-water solvent mixture. J. Am. Oil Chemists' Soc. 38, pp. 497-500.

King, William H. and Frampton, Vernon L. March 13, 1962. Recovery of oil from acetone-hexane-water mixed solvent extracts of raw cottonseed meats. U. S. Patent No. 3,025,314.

King, William H., Kuck, James C. and Frampton, Vernon L. 1961. Properties of cottonseed meals prepared with acetone-petroleum ether-water azeotrope. J. Am. Oil Chemists' Soc. 38, pp. 19-21.

King, W. H., Kuck, J. C. and Frampton, V. L. 1962. Lysine, gossypol and nitrogen solubility in chemically treated cottonseed meals. J. Am. Oil Chemists' Soc. 39, pp. 58-60.

Mann, G. E., Carter, F. L., Frampton, V. L. (Southern Utilization Research and Development Division), Watts, A. B. and Johnson, Charles (Louisiana State University). 1962. Evaluation of cottonseed meals prepared by extraction with acetone-hexane-water mixtures. J. Am. Oil Chemists' Soc. 39, pp. 86-90.

Martinez, Wilda H., Frampton, Vernon L. (Southern Utilization Research and Development Division) and Cabell, C. A. (Animal Husbandry Research Division, Beltsville, Maryland). 1961. Nutritive quality of cottonseed meals. Effects of gossypol and raffinose on lysine content and nutritive quality of proteins in meals from glandless cottonseed. J. Agr. Food Chem. 9, pp. 64-66.

Teunisson, Dorothea J. 1961. Microbiological assay of intact proteins using tetrahymena pyrifommis W 1. Survey of protein concentrates. Anal. Biochem. 2, pp. 405-420.

New and Improved Industrial Products and Processing Technology

Magne, Frank C., Mod, Robert R. and Skau, Evald L. 1961. Fatty acid morpholides as plasticizers for vinyl chloride resins. II. The morpholides of selectively hydrogenated and of epoxidized cottonseed fatty acids. J. Am. Oil Chemists' Soc. 38, pp. 291-293.

Magne, Frank C., Mod, Robert R. and Skau, Evald L. 1961. Fatty acid morpholides as plasticizers for vinyl chloride resins. III. Ternary compatibility-composition diagrams for the oleic-linoleic-stearic and oleic-linoleic-palmitic systems. J. Am. Oil Chemists' Soc. 38, pp. 294-296.

Mod, Robert R., Magne, Frank C. and Skau, Evald L. 1960. Pure acid-free amides of C_{18} fatty acids. Their preparation and binary freezing point behavior. J. Chem. Eng. Data 5, pp. 478-479.

Mod, Robert R., Magne, Frank C. and Skau, Evald L. 1960. Freezing point data for a portion of the ternary system: Acetamide-palmitic acid-stearic acid. J. Phys. Chem. 64, pp. 1613-1616.

Mod, Robert R., Magne, Frank C. and Skau, Evald L. 1962. Binary freezing point behavior of some N-substituted amides of palmitic, stearic, oleic, and linoleic acids. J. Chem. Eng. Data 7, pp. 31-32.

Skau, Evald L., Mod, Robert R. and Magne, Frank C. September 6, 1960. Purifying and stabilizing acids and amines. U. S. Patent No. 2,951,859.

PEANUTS PROCESSING AND PRODUCTS
Southern Utilization Research and Development Div., ARS

Problem. Peanuts constitute a major cash crop in the Southern States and are in surplus. Because of the high price of peanuts in the United States, peanuts are used almost exclusively (more than 80 percent of the crop) in foods such as peanut butter, confections, and roasted and salted nuts. New type food products and improvement in the quality and uniformity of existing products are needed to increase consumer acceptance and extend markets; the average per capita consumption has been rather stable since World War II. The increased trend toward mechanical harvesting has necessitated the use of artificial means for curing and drying peanuts, with the result that processed peanuts and peanut products do not always possess the same desirable flavor and physical properties as peanuts which have been cured slowly in the field. Information is needed as to the physical and chemical characteristics of those chemical constituents in peanuts which affect the properties of processed products as a basis for developing new or improved products and processing procedures. Fundamental studies of peanut protein and associated materials could similarly lead to the development of new concepts and new uses.

USDA PROGRAM

The Department has a continuing long-term program involving organic chemists, biochemists, and chemical engineers engaged in both basic and applied studies on peanuts and its products to increase consumer acceptance and extend markets for peanuts. Research to develop basic information on the chemical composition and properties of peanuts, its constituents, and processed peanut products is carried out at New Orleans, Louisiana. Fundamental investigations of peanut proteins and associated materials are conducted to form the basis for developing new concepts and perhaps new uses for peanuts and peanut proteins. Peanut constituents and their modification by processing that influence nutritive properties and consumer acceptance of processed peanut product are also studied. The Crops Research Division of ARS and several State Experiment Stations, including Georgia, Alabama, and Texas, cooperate in the research by providing samples of peanuts of known variety and of known growing, harvesting, and drying histories. Louisiana State University cooperates by conducting evaluation tests on selected peanut isolates. Research on new and improved food products, and new and improved processing technology for peanuts are conducted at New Orleans, Louisiana. In the food products work, emphasis is on obtaining a stable, defatted whole peanut (kernel) product of long shelf life, which also meets the requirements of taste, odor, color, texture, and appearance. Several industrial concerns specializing in peanut products cooperate by supplying deskinned peanuts and by evaluating the experimental products. The processing research consists of investigations of procedures for large scale production of defatted whole peanuts. Industrial concerns are cooperating in the determination of the necessary processing conditions for such operations as desolventization and roasting.

The Federal scientific research effort in this area totals 5.1 professional man-years. Of this number 4.1 is devoted to chemical composition and physical properties, 0.5 to new and improved food products, and 0.5 to new and improved processing technology.

The following line of work was terminated during the year: (1) Investigations to isolate, identify and measure chemical constituents in peanuts which contribute to quality of processed peanut products (under chemical composition and physical properties).

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 2.2 professional man-years effort, divided among subheadings as follows: chemical composition and physical properties, 0.7; new and improved food products, 1.2; and new and improved processing technology, 0.3.

One State Experiment Station is investigating chemical composition and physical properties of peanuts as these relate to susceptibility of various strains of Spanish peanuts to rancidity development. Determination of phosphorus content, level of free fatty acids and susceptibility of oils to autoxidation has been made for peanuts of known genetic history and maturity in a search for means of control at the genetic level. A second program includes a comprehensive investigation of the chemical composition of peanuts as composition is affected by enviornmental and agronomic factors. Flavor of peanuts is also being determined in an effort to note any effects due to production practices or handling.

Two main phases of work are underway on new and improved peanut food products. One phase is directed toward development of more dependable and efficient methods of curing peanuts which will yield peanut products of high quality and free of bitterness; the second seeks to determine the effect of various treatments (temperature, time, moisture and storage conditions) upon the keeping qualities of peanuts and peanut products in common and refrigerated storage. In the latter study, the influence of variety, grade and prestorage quality of peanuts on processing characteristics and on shelf-life of peanut products is also obtained.

Aroma and flavor characteristics of peanuts are developed from the basic constituents of raw peanuts by reaction at roasting temperatures. One station is conducting research on improved processing technology for peanuts by investigating the chemistry of the process of roasting peanuts and the effect of variations in roasting on the resulting product. It is expected that characterization of the substances responsible for the aroma and flavor of roasted peanuts will lead to identification of the precursors of flavor and aroma to be found in raw peanuts.

Industry and other organizations also conduct research of interest and value in this area. The estimated annual expenditures are equivalent to approximately 8 professional man-years. Of this total, about 6 man-years is by processors and 2 man-years by equipment manufacturers. For the most part food processors are engaged in improving peanut butter and peanut-containing confections. Research is directed toward improvements in the texture, appearance, and mouthing properties of peanut butter and in the stability, appearance, texture and flavor of roasted or salted peanuts and of peanut-containing products. A limited amount of attention is being given to processing peanut oil for edible purposes and to peanut flour as a food constituent. There is limited effort on the part of the industry to develop fundamental information on peanuts either as a food item or as a potential raw material for industrial use. Frequently such information is sought from the Southern

Utilization Research and Development Division by representatives of the industry. Information concerning problems of the peanut industry is exchanged through representatives of the National Peanut Council and of the industry at meetings of the Peanut Improvement Working Group. Some attention is given by equipment manufacturers to improving equipment for shelling and grading peanuts with respect to size and color, and for blanching and roasting.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Structural Factors, Properties, and Reactions of the Proteins. Pioneering research in scientific fields involving seed proteins and associated substances was continued as a basis for development of new concepts and possibly new uses for these materials. Major areas of recent research have included studies of seed globulins, of their subcellular distribution, and of a specific group of seed proteins, the lipases.

Research on isolation and chemistry of seed globulins has shown that ultracentrifugation is sensitive to protein interaction and, therefore, is a relatively unreliable method for analyzing seed proteins. It has been found possible, however, to apply chromatography on DEAE cellulose and the new technique of zone-electrophoresis on Cyanogum gel to the total proteins of the peanut. In both these instances these methods are much less subject to protein interaction and may be relied upon to reflect accurately the composition of mixtures and the progress of fractionation. With the aid of these two tools and by scaling up the process of chromatography, it has been possible to isolate a pure globulin from peanuts which has been named α-conarachin, and which is now being studied extensively for structure and composition. This globulin disappears from the peanut in the first few days of germination as shown by chromatography, and it is very sensitive to the environment - by simply changing ionic strength and pH molecular weights varying from 145,000 to 500,000 are obtained. In the presence of low concentrations of sodium dodecyl sulphate or concentrated urea, particles of molecular weights of less than 10,000 can be noted. This leads to the belief that the major primary unit is of low molecular weight, and that perhaps several types of primary units go in to make the final major structure.

One of the classical seed proteins, edestin from hempseed, has now been shown to be a mixture by cellulose chromatography at elevated temperatures. This procedure opens the way for chromatography of insoluble proteins without resorting to extremes of pH. This procedure is being employed to isolate pure proteinsfrom hempseed.

Two independent methods have been developed for subcellular fractionation of the contents of the peanut parenchyma cell. The first method which involves fractionation in the absence of water has resulted in obtaining protein rich particles with protein concentrations up to 85%. These particles do not exhibit any enzymatic activity. However, protease activity has been found in the cell wall fraction, and hexokinase activity in a fines fraction. A second fractionation using concentrated sucrose and Carbowax solutions has demonstrated that about 75% of the protein of the peanuts are in subcellular particles, and are not released into solution in the presence of the aforementioned asomatic agents. Among these proteins is α-conarachin. A new

approach has therefore been made available for studying the biological function of the major seed globulins which have been shown to be in subcellular particles - by isolating and studying the biochemistry of the particles themselves.

In the course of these studies, unique distributions of components have been found. For example, all of the phytic acid is found in a protein rich component (aleurone grains), as well as the greater proportion of magnesium and potassium. The major proportion of calcium is found in the cell walls and the major amount of sucrose and nucleic acids in the fines fraction (reticulum).

The mobilization of fat in oilseeds takes place rapidly in the early days of germination and is one of the important physiological processes for mobilization of energy to support the growth processes. The first step in the mobilization is lipolysis of the glyceride, or otherwise making available the acyl group for further metabolism. The proteins involved in this process have been investigated in two lines of research: (1) the study of lipolysis in resting seeds as observed in the castor bean; (2) study of the development of lipolytic systems in germinating seed. For the purpose of comparison, the castor bean was chosen for this study as well.

The study of the lipase in castor beans has resulted in the isolation of a particulate preparation which contains the acid lipase free of all substrate, and of most of the other proteins. This preparation is very active and quite stable. There seems to be evidence of two enzymes in this preparation: one with a maximum activity for triglycerides of C_6 saturated fatty acids and the other with maximum activity for glycerides of long-chain unsaturated fatty acids. One of the problems in understanding the catalysis of heterogeneous reactions involving water and insoluble material such as fat, is to find the means of bridging between the two in the catalytic action. Accordingly, one phase of the research has sought the removal of a factor from the enzyme which might perform this function. Success has been achieved in removing from the acid lipase a lipid material which acts as a cofactor for hydrolysis of triglycerides of long-chain fatty acids. This is the first time that a cofactor for a lipase has been reported. And this work has taken an exciting turn with the finding that α-tocopherol succinate can substitute for this lipid cofactor. This is the first time that an enzymatic role for tocopherols has been found.

The lipase of the resting castor bean is more typical of lipolysis in animal or plant adipose tissue than is the lipase of the gastrointestinal tract. Information on the properties of the castor bean lipase will therefore have general meaning, not only for plant tissue lipases, but possibly also for animal lipases. The fact that tocopherol is involved in lipase activity might even suggest a role for tocopherol in a field so far away from the original purpose of investigation as atherosclerosis.

The methods used to study the fatty acid content of serum lipids have been applied to the germinating castor bean. It has been shown that there is a sharp increase in fatty acid content up to four days of germination, following which the fatty acid content decreases sharply. This will be the basis for selection of ideal conditions for isolation of the lipase in the germinating seed.

2. Identification of Factors Influencing Flavor, Aroma, Color, Structure, and Nutritive Value of Processed Products. In contract research at the University of Arizona, which is now terminated, investigations were continued to study the influence of processing on the composition and flavor of peanut products. The concentrations of free arginine, histidine, aspartic acid, lysine, proline, serine and threonine were determined through the use of ion exchange methods for the roasted fat-free peanut flours for the 1957 and for the 1958 crops of the varieties Argentine, Florispan Runner, Fla. 302-12-B-28, Tennessee Red and Dixie Runner. Arginine, histidine and lysine determinations were made on two varieties of peanuts from the 1957 crop and on the five varieties of the 1958 crop in the "uncured, dried and refrigerated" treatment. The free alanine, aspartic acid, glutamic acid, glycine, proline, serine, cystine, threonine and valine were determined on the flour obtained from "uncured, dried and refrigerated," and for the "cured, refrigerated" for the 1957 and 1958 crops. Non-protein, total and amino nitrogen, total sugar, and oil contents were also determined for all treatments for the five varieties.

The data for the free amino acids in the peanuts as determined by ion exchange methods and by microbiological methods were not in agreement. This points to the fact that microbiological methods may not be relied upon in the determination of free amino acids in plant extracts. Evidence for the reduction of the amino nitrogen in peanut proteins on the roasting of peanuts suggests that lysine may be affected by the roasting process. No clear cut pattern of a relationship between the free amino acids in peanuts and the quality factors such as aroma, flavor, color and texture evolved from the studies. The wide variation in the intensity of the quality factors observed in the samples studied indicate that sampling of peanuts over wide geographical areas and growing conditions is essential for quality comparisons of varieties and for the ultimate correlation of quality factors and constituents of raw peanuts.

As an aid to better understanding and assessing the quality factors of processed peanut products, further in-house research was conducted on the isolation and characterization of chemical constituents in peanuts which might affect nutritive properties and consumer acceptance. The myotonic factor in peanuts has been concentrated 15,000-fold. Its physiological activity is lost on mild acid or alkaline hydrolysis. This material has been shown by paper chromatography to consist of two major components and at least one minor one. One of the crystalline materials isolated in the course of fractionation of the alcohol extract of de-oiled peanuts was identified as pinitol, a monomethyl ether of D-inositol. Investigations will be continued to identify the hemostatic factor and other crystalline products in the alcohol extract. The physiological tests on various peanut fractions are carried out in the Department of Zoology at Louisiana State University. (S4 1-87, S4 1-100).

B. New and Improved Food Products

1. Defatted Whole Peanuts. Research to develop defatted whole peanuts (kernels) as a new confection was conducted. Interest in defatted peanuts is due to several factors, including lower caloric value, possible increase in shelf-life by minimizing oil rancidity, possible use by hemophiliacs to control bleeding, and opportunity for increased utilization of peanuts.

Roasted Virginia peanuts were solvent extracted with hexane to different levels of oil removal, and then desolventized. Some of the samples of defatted desolventized peanuts were salted, either by dipping in saturated salt solution at room temperature or preferably by dipping in water and sprinkling with salt. The wet peanuts were oven dried. The most acceptable product (salted or unsalted) proved to be the defatted peanuts with 81% oil removed. The peanuts have a good appearance, and their taste is considered acceptable even though it is not like that of the original roasted peanuts. Packaging of the product in metal cans, in either vacuum or in an atmosphere of nitrogen containing less than 2% oxygen, maintained the peanuts in good condition even after one year storage time. In cellophane-type packages, defatted peanuts tended to pick up excessive moisture within 30 days. Other types of flexible packaging are being investigated.

C. New and Improved Processing Technology

1. Processing Technology Related to Defatted Peanuts. Based on earlier laboratory experiments in producing defatted peanuts, pilot-plant runs were conducted to prepare large amounts of materials for taste and appearance evaluation, to obtain pilot-plant processing data for cost calculations, and to investigate practical methods of desolventization of the extracted peanuts and other processing steps. Fully roasted and one-half roasted Virginia peanuts were batch extracted with hexane for 23, 47, 71, 120, and 335 hours at room temperature to remove 38, 61, 71, 81, and 92% oil, respectively. The fully roasted peanuts with 81% of the oil removed have the best appearance. Low rates of extraction indicate that a batch method would be required for large scale processing.

The extracted, solvent-wet peanuts were desolventized by (1) air drying followed by drying in a forced draft oven at 150° F. and then at 212° F., (2) direct drying in a force draft or vacuum oven at a low initial temperature of 150-167° F. followed by 212° F., or (3) direct drying in a forced draft or vacuum oven at 212° F. Drying at a lower initial temperature appears to give a better tasting defatted peanut especially when a forced draft oven is used. A minimum total drying time of 9 hours is required to remove the last traces of solvent.

A preliminary cost study for defatting Virginia peanuts with hexane in three all-new hypothetical commercial plants indicates operating cost can be as low as 74 cents for a volume equivalent to the 14 oz. pack popularly merchandized in 503 x 308 tins. Using fully depreciated equipment reduces operating cost of the equivalent of the 14 oz. pack to 61.5 cents.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Chemical Composition and Physical Properties

Altschul, A. M., Snowden, J. E., Jr., Manchon, D. D., Jr. and Dechary, J. M. 1961. Intracellular distribution of seed proteins. Arch. Biochem. Biophys. 95, pp. 402-404.

Boudreaux, H. B., Boudreaux, R. M., Brandon, Martha (Dept. Zoology, LSU), Frampton, Vernon L. and Lee, Louise S. 1960. Bioassay of a hemostatic factor from peanuts. Arch. Biochem. Biophys. 89, pp. 276-280.

Dechary, J. M., Talluto, K. F., Evans, W. J., Carney, W. B. and Altschul, A. M. 1961. α-Conarachin. Nature 190, pp. 1125-1126.

Dieckert, Julius W., Snowden, James E., Jr., Moore, Anna T., Heinzelman, Dorothy C. and Altschul, Aaron M. 1962. Composition of some subcellular fractions from seeds of arachis hypogaea. J. Food Sci. 27, pp. 321-325.

Evans, W. J., Carney, W. B., Dechary, J. M. and Altschul, A. M. 1962. Zone electrophoresis of conarachin, α-conarachin and bovine serum albumin on polyacrylamide gel. Arch. Biochem. Biophys. 96, pp. 233-239.

Morris, Nelle J. and Lee, Louise S. 1961. Peanut flour constituents. Isolation and identification of a sterol glucoside from peanut flour. J. Agr. Food Chem. 9, pp. 401-403.

Ory, Robert L. 1961. The separation of glycerides of mixed fatty acid chain length by glass paper chromatography. J. Chromatography 5(2) pp. 153-156.

Ory, Robert L. and Altschul, Aaron M. 1962. Participation of tocopherol derivatives in lipolysis. Biochem. & Biophys. Res. Commun., 7, pp. 370-374.

Ory, Robert L. and Altschul, Aaron M. 1962. A lipid cofactor for the acid lipase of the castor bean. Biochem. & Biophys. Res. Commun. 7, pp. 375-379.

Ory, Robert L., St. Angelo, Allen J. and Altschul, Aaron M. 1962. The acid lipase of the castor bean. Properties and substrate specificity. J. Lipid Research 3, pp. 99-105.

General

Altschul, Aaron M. 1961. Present status of proteins from oilseeds. Natl. Acad. Sci. Natl. Research Council Publ. 843, pp. 517-530.

Altschul, Aaron M. 1962. Seed proteins and world food problems. Econ. Botany 16, pp. 2-13.

TUNG PROCESSING AND PRODUCTS
Southern Utilization Research and Development Div., ARS

Problem. Tung oil has lost much of its traditional market in protective coatings to synthetic raw materials. New and improved industrial products from tung oil must be developed to recapture lost markets, maintain present markets, and provide new outlets for surplus tung oil. Basic information is needed on the chemical composition and properties of tung oil and its fatty acids, and on the chemical modification of these materials to permit more effective exploitation of their unique characteristics in protective coatings, agricultural and industrial chemicals, surfactants, and plasticizers. For example, improved coatings utilizing tung oil are needed to meet increased performance demands and competition from synthetic polymeric coatings. Intumescing fire-retardant coatings and water-reducible coatings containing tung oil are desired. A limited market of low economic value exists for tung meal as a fertilizer. Research is needed to develop more information on the profitable industrial uses for tung meal and its protein to the benefit of the overall economy of the tung industry.

USDA PROGRAM

The Department has a continuing long-term program involving organic chemists engaged in both basic and applied research on tung and its products. Emphasis in the present program is on development of new and improved industrial products from tung oil and its derivatives.

Research is conducted at New Orleans, Louisiana to develop fundamental information on the chemical composition, properties, structural factors and reactions of oilseed proteins, as a basis for development of new concepts and possibly new uses for oilseed proteins, including tung protein. Research to develop new and improved industrial products from tung oil is carried out at New Orleans, Louisiana, with cooperation and support by the Pan American Tung Research and Development League, the U. S. Army Engineers Research and Development Laboratories and the U. S. Air Force. The league maintains a part-time Fellow at the Southern Regional Research Laboratory for research on the production of improved protective coatings from tung oil. The major emphasis is placed on the development of exterior, intumescing fire-retardant surface coatings using tung oil alkyds. The tung alkyds are being chemically altered and formulations modified to produce coatings which will intumesce to give a thick cellular, fire-resistant material upon thermal or flame exposure. The U. S. Army Engineers Research and Development Laboratories evaluate the more promising fire-retardant coating formulations developed with their support. Other investigations involve studies of the chemical modification of tung oil and its fatty acids to produce chemical intermediates having utility in protective coatings, and as agricultural chemicals, surfactants or plasticizers. Informal cooperation is maintained with industrial firms and other agencies for the evaluation of promising chemical intermediates for specific end uses.

The Federal scientific research effort in this area totals 4.8 professional man-years. Of this total 0.6 is devoted to chemical composition and physical properties, and 4.2 to new and improved industrial products.

The following line of work was terminated during the year: (1) Applications research on vehicles and surface coatings containing derivatives of tung oil (under new and improved industrial products).

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 did not report any effort in this area of research.

Industry and other organizations conduct limited research in this area, the estimated annual expenditures in the United States being equivalent to approximately 9 professional man-years. Of this total about 4 man-years' effort is by the Pan American Tung Research and Development League, 3 man-years by the protective coatings industry, and 2 man-years by chemical concerns.

Research to develop new or improved products from tung oil is being supported cooperatively by tung growers and processors in the United States and Argentina at their Pan American Tung Research and Development League Laboratory at Picayune, Mississippi, and elsewhere by contracts. Under development are water-thinnable tung oil paints for the automotive industry, products from oxidized tung oil, and plastics. The League supports a part-time Fellow at the Southern Utilization Research and Development Division and there is frequent exchange of information on research developments.

Although over 80% of tung oil consumption is in the protective coatings industry, this industry's research effort on tung oil is quite limited since it has no vested interested in tung oil and there are many competing raw materials from which to choose. Several producers of emulsion-type paints or polymers for such paints are evaluating emulsifiable tung oil as an additive to improve adhesion in repainting chalky surfaces.

One large chemical concern is conducting research to develop uses for their recently introduced product, an acrolein adduct of tung oil. Exploratory work on this type adduct was carried out at the Southern Division. Several companies have been furnished samples of tung monoglycerides prepared at the Division for evaluation as an emulsifier-sticking agent for insecticides and one company has produced tung monoglycerides on a laboratory scale.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Structural Factors, Properties and Reactions of the Protein. The composition, properties, structural factors and reactions of oilseed proteins and associated materials are being investigated as a basis for development of new concepts and possibly new uses for oilseed proteins, including tung protein. Major areas of recent research have included studies of seed globulins, of their subcellular distribution, and of a specific group of seed proteins, the lipases. Since peanuts were found to be an especially suitable experimental material and employed for much of the fundamental research on seed proteins, the report of progress in the research is given in Area No. 7, "Peanuts Processing and Products."

B. New and Improved Industrial Products

1. Exterior Intumescing Fire-Retardant Surface Coatings from Tung Oil Alkyds. More than 11,000 lives are lost annually in the United States by fire, and our property losses by fire amount to over one billion dollars a year. Effective fire-retardant protective coatings could greatly reduce this loss of life and property.

Research supported in part by the U. S. Army Engineers Research and Development Laboratories and the U. S. Air Force, and assisted by a part-time Fellow of the Pan American Tung Research and Development League, has been continued to develop exterior, intumescing fire-retardant protective coatings from tung oil alkyds. The fire-retardant paints previously prepared from tung oil alkyds and various types of gas-producing components have been modified to improve their thermoplastic, fire-resistant and intumescent properties. Improvements were achieved by lowering the pigment-vehicle ratio, by modification of the binder, and by incorporating better gas-producing and fire-resistant components in the undercoat. However, these multiple formulation, two- or three-coat paint systems (gas-producing undercoat, covered with a resistant topcoat) still lacked the desired foam-forming, carbon-forming and fire-resistant properties.

In more recent work, encouraging progress was made in preparing intumescing fire-retardant films using single formulation, two- or three-coat, foam-forming paint systems. This was achieved by incorporating water-insoluble or relatively water-insoluble organophosphorus, organohalophosphorus, organonitrogen and polyhydroxy and polyurethane derivatives into the formulations. Previously, it was impossible to prepare intumescing fire-retardant paint films with a single formulation system. A resistant topcoat formulation was always necessary to trap some of the evolved gas. The new foam-forming formulations produce coatings exhibiting remarkable water resistance. In some cases the water resistance is actually improved by exposure to water. Preliminary tests indicate that films of these paints also have good thermal shock resistance and recoatability. When evaluated in USAERDL's fire-test cabinet (a relatively mild test), many of the paint formulations exhibited good intumescing fire-retardancy. However, when the best formulations were tested in the more severe Forest Products Laboratory's 8-foot tunnel furnace, only limited fire-retardancy was obtained. This pointed to the necessity of developing a more rigorous laboratory fire-retardancy screening test than the conventional fire-test cabinet method. A simple, yet severe screening test has been developed at the Southern Regional Research Laboratory. Using the test as a guide, improved fire-retardant coatings have been made. One recent formulation exhibited fairly good fire-retardancy when tested in the 8-foot tunnel furnace. Further improvements in spumific (foam-forming) and carbonific (carbon-forming) fire-retardancy action, can stability, brushability, drying characteristics, color and tint retention, water resistance, mildew resistance, and weatherability will be sought. (S4 1-98)

2. Chemical Modification of Tung Oil to Produce New and Improved Products Such as Protective Coatings, Agricultural Chemicals, Surfactants and Plasticizers. Tung oil and tung methyl esters adducted with acrylic acid were formulated into water dispersible alkyds by cooking with polyethylene glycol, a triol, and phthalic anhydride. The aqueous dispersions at 33% solids content were stable on aging and to freeze-thaw cycles. With melamine resin,

they formed films which could be baked to give coatings having good hardness, adhesion and flexibility, and resistant to water, salt water, detergent, mineral spirits, and gasoline. The formulations have good possibilities for use as primers but are not sufficiently resistant to ultraviolet light for use as finish coatings.

Evaluation of tung oil-zinc resinate-pentalyn G varnish vehicles, in which one-third or one-half of the zinc resinate was replaced with lead resinate, showed that the drying times were appreciably reduced. The promising new formulations are comparable to standard modified phenolic resin varnishes and fast drying alkyd resins.

Under contract work (now terminated) at the University of Florida concerned with applications research on vehicles and surface coatings containing derivatives of tung oil, tung monoglycerides in combination with ammonium eleostearate or ammonium oleate were evaluated as dispersing agents for pigments in typical resin emulsion paints. Tung monoglycerides and ammonium oleate, in combination with commercial dispersing agent Tamol 731 in an acrylic type resin emulsion, gave a coating with somewhat better water resistance than that produced with commercial dispersing agents. (S4 1-78(C)).

Limited research has been carried out under a new project whose objective is to chemically modify tung oil and its fatty acids to produce materials having utility as agricultural chemicals, surfactants or plasticizers, and in protective coatings. Preliminary experiments indicate that it may be possible to obtain a paint oil of improved water resistance and brushing characteristics by heat processing tung and soybean oil at low temperature in the presence of a catalyst. This will require confirmation. It is planned to direct the research initially toward development of an air drying, water reducible tung oil vehicle as a protective coating. The Pan American Tung Research and Development League supplies a part-time Fellow who gives advice and assistance in the production of improved protective coatings. (S4 1-93).

PUBLICATIONS REPORTING RESULTS OF USDA & COOPERATIVE RESEARCH

Chemical Composition and Physical Properties

Holmes, R. L. and O'Connor, R. T. 1961. Chemical and physical characteristics and possible configuration of toxins from tung kernels. J. Am. Oil Chemists' Soc. 38, pp. 520-523.

New and Improved Industrial Products

Decossas, K. M., Eaves, P. H., Koltun, S. P., Pollard, E. F., and Patton, E. L. 1960. Tung oil-resin varnish vehicle--a preliminary cost analysis. Paint Varnish Production 50(8), pp. 33-36, 83.

Dollear, Frank G. 1960. Developing new products from tung oil. Proc. 27th Annual Convention Am. Tung Oil Assoc. 27, pp. 21-23

Dollear, F. G. and Hopper, L. L., Jr. 1961. Fire retardant paint. Proc. 28th Annual Convention Am. Tung Oil Assoc. 28, pp. 14-15.1/

1/ Publication resulting from research supported by funds transferred from the U. S. Army Engineers Research and Development Laboratories.

Eaves, Paul H., Spadaro, J. J., and Patton, E. L. 1960. Preparation of varnish and varnish-type vehicles containing tung oil. Paint varnish Production 50(8), pp. 27-30, 82-83.

Eaves, P. H., Spadaro, J. J., Cirino, V. O., and Patton, E. L. 1961. A monoglyceride-rich tung oil product. J. Am. Oil Chemists' Soc. 38, pp. 443-447.

Goldblatt, Leo A. and Hopper, Lucien L., Jr. May 16, 1961. Paint vehicle with fungicidal properties. U. S. Patent No. 2,984,632.

Goldblatt, Leo A., Hopper, Lucien L., Jr. and Rayner, Eric T. September 5, 1961. Process for simultaneous alcoholysis and gasproofing of tung oil. U. S. Patent No. 2,999,104.

Goldblatt, Leo. A., Hopper, Lucien L., Jr., and Rayner, Eric T. November 14, 1961. Process for simultaneous alcoholysis and gasproofing of tung oil, and production of alkyd resins therefrom. U. S. Patent No. 3,008,910.

McKinney, Robert S. and Goldblatt, Leo A. May 1, 1962. Ammonium soaps of tung oil fatty acids as a fugitive emulsifier and sticking agent. U. S. Patent No. 3,032,467.

Placek, Lida L. and Bickford, W. G. 1960. The reaction of divinyl sulfone with alpha-eleostearic acid. J. Am. Oil Chemists' Soc. 37, pp. 400-402.

Placek, Lida L., Pastor, H. P., Hughes, J. P., and Bickford, W. F. 1961. Divinyl sulfone-eleostearate adducts as plasticizers for nitrile rubber. J. Am. Oil Chemists' Soc. 38, pp. 107-109.

Root, Frank B. and Amidon, Roger W. (U. S. Rubber Co.). 1960. Tung oil and its derivatives in polyesters. Mod. Plastics 38(2), pp. 144, 146, 149-150.

CASTOR, SAFFLOWER AND OTHER WESTERN OILSEEDS PROCESSING AND PRODUCTS

Western Utilization Research and Development Div., ARS

Problem. To provide valuable diversification crops for the acreage withdrawn from the production of cotton, wheat, feed grains, and other surplus crops, there is a critical need to expand the markets for crops such as castor and safflower. But these crops are so new to our agricultural economy that their market potential has not been adequately developed. Castor and safflower have good potential because of the unusual properties of their oils. The possibility of large-scale increases in the production of these oilseeds would be strengthened if high-quality feed products could be developed from the oilseed meals. Basic information is needed on the composition of the oils and of the meals left after extraction of the oil, and this, in turn, requires the development of adequate analytical methodology. Rapid and accurate analytical methods are needed to control and improve the processing of the oils and meals for food, feed and industrial applications. Research on chemical conversion of the oils and evaluation of the modified products is needed to find new or improved large-volume uses. The high percentage of linoleic acid (essential fatty acid) in safflower oil points to a rapidly expanding usage as a food oil. But this same fatty acid imparts a high degree of susceptibility to autoxidation. Research is needed to stabilize safflower oil in various types of food products. Improved procedures for decorticating and processing castor and safflower seeds are needed. There is a particularly critical need to develop methods for the removal or destruction of the allergenic and toxic components of castor meal which presently limit its use to fertilizer. Research to isolate and characterize the constituents in castor and safflower meals is needed to develop non-toxic, non-allergenic feed and food products of high value. Basic and applied research is needed to prepare chemically modified products from the meals for industrial applications, to develop economical procedures for carrying out the modifications, and to evaluate the modified products.

USDA PROGRAM

In the Western Utilization Research and Development Division, both basic and applied research are conducted on castor seed at the Division headquarters at Albany, California and, under contract, at Tucson, Arizona and Menlo Park, California. Basic, compositional studies on castor seed meal are concerned with the resolution of its water-soluble proteins and determination of the allergenic and antigenic properties of these components. Studies are conducted on the composition of castor oil, and new analytical techniques are developed.

Applied research on castor meal has as its objective the development of economical methods for deallergenizing the meal without impairing its nutritive quality, to increase its value as an animal feed ingredient. Castor oil and its major constituent, ricinoleic acid, are being studied to provide for them new and improved industrial applications. Thus, methods are being developed for the preparation of various types of polyurethane foams incorporating castor oil or its derivatives. Procedures are also being devised for the preparation of chemical derivatives of ricinoleic acid, including a number of amides and phosphate esters. Several of the latter compounds may be useful for improving the flame-resistant properties of castor-based polyurethane foams of the type which may be used for building insulation. The utility of various polymerizable monomers, derivable from castor oil, for the production of synthetic polymers for use in rubbers, plastics, etc., is being investigated under contract.

The Federal program of research in this area totals 11.5 professional man-years. Of this total, 4.8 are assigned to chemical composition and physical properties; and 6.7 to new and improved products.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported 0.4 professional man-years of research on chemical composition and physical properties. This research is designed to evaluate the practicability of producing animal feed from castor pomace, by removing toxins and allergens. This program, which is cooperative with the USDA and industry, also includes studies of the biosynthesis of the alkaloid, ricinine, and the amino acid content and biological value of castor seed protein.

Industry and other organizations are estimated to be conducting research on castor with expenditures equivalent to about 14 professional man-years. Most of this effort is directed, by oilseed processing and chemical companies, toward the development of new industrial uses for castor oil and its derivatives. Only negligible effort is being expended on basic research on castor, either by industry or academic institutions. About 10 professional man-years of effort are being applied by industry to research on safflower. Until very recently, most of this research was devoted to developing increased industrial and feed outlets for safflower oil and meal. Increased effort is now being directed toward the utilization of the oil in edible products where it is valued for its high content of linoleic acid.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Allergenic and Antigenic Proteins. Under a contract project, concluded during this reporting period, information was obtained on the preparation and chemical properties of the highly allergenic protein complex of castor seed meal. A quantity of this material, produced by the contractor, was fractionated and characterized by several techniques. Each of these antigenic fractions was shown to be an extremely potent allergen for humans sensitive to castor. Deallergenization of castor meal will, therefore, require the inactivation of all of the antigenic materials present. Treatment of castor meal to convert these protein materials into innocuous compounds would be expected to affect other proteins present and thus lower the nutritive value of the treated meal. More detailed information regarding the chemical composition of the antigenic proteins could possibly lead to the development of selective inactivation procedures to avoid destruction of nutritionally valuable proteins. Studies on the isolation and characterization of the individual antigens of castor are in progress, under contract, at the Stanford Research Institute. Although hanging curtain electrophoresis can be used to resolve a partially purified allergen complex into a number of discrete fractions, the technique fails in use with the crude allergen mixture. For this reason, methods are being examined for accomplishing a subfractionation of the crude mixture preparatory to electrophoretic separation of discrete antigens. Confirmation has been obtained of preliminary findings that castor pollen, female flower blossoms, and seed proteins cross react. Thus, castor pollen can sensitize an individual to the meal (and vice versa). This may explain the puzzling cases of individuals with no history of prior exposure to castor meal showing symptoms of allergy when exposed for the first time. It was also shown that castor-allergic individuals react to, and may have been sensitized by, other members of the family Euphorbiaceae (spurges). It appears that allergy to castor meal is probably a complex of allergies traceable to both the castor antigens, and the antigens that may be present in a wide variety of contaminating materials, especially when castor is harvested mechanically.

2. Detection of Allergenicity and Antigenicity. The study of the composition of the individual antigenic proteins of castor requires a reliable allergy assay technique. Such an assay is also necessary for evaluating the effectiveness of methods being tested for deallergenizing castor meal. It was shown early in this work that the commonly-used Schultz-Dale *in vitro* assay for allergenicity was of little value because of its lack of specificity. In addition to the truly antigenic proteins of castor, a factor is also present which produces a non-specific, histamine-like response resulting in a positive Schultz-Dale test even in the absence of a true allergenic

reaction. Testing allergens or antigens on humans is a highly undesirable procedure because of the risk of allergic shock or hepatitis infection. For these reasons an animal assay technique has been developed which has been shown to be accurate, specific, rapid and relatively inexpensive. This technique depends upon the phenomenon of passive cutaneous anaphylaxis (P.C.A.). It is this phenomenon which causes a local sensitization in the skin of a non-allergic individual following the injection of blood serum from an allergic individual. The sensitized skin sites will often exhibit an inflammatory reaction with wheal formation, upon direct injection into the site of a minute quantity of the substance (antigen) causing allergy in the serum donor. The inflamed area of the skin can be made highly visible by the intravenous injection of a colloidal dye, such as Evans Blue, prior to challenging with the antigen. Because the minute blood vessels in the inflamed area exhibit increased permeability, dye leaks into the extravascular spaces in the skin and a blue spot appears, indicative of a positive allergy test. This technique was developed using rabbit antisera in the skins of guinea pigs but has since been extended to two species of monkeys. Results have indicated an essentially perfect direct correlation of the P.C.A. tests with observations on humans. The validity of the monkey P.C.A. test has been demonstrated with known and probable contaminants of castor meal. It was successfully applied to the detection of allergies due to castor plant pollen, ragweed, animal danders, cereal grains, grass pollen, and insects commonly associated with castor beans. This technique will, therefore, enable investigators to differentiate between true castor allergy and reactions to contaminating components of castor meal.

3. Fatty Acids of Castor Oil. New and improved methods have been developed for the analysis of mixtures of fatty acids or their derivatives. The thin layer chromatostrip technique has been adapted and used effectively in combination with suitable detection systems for identifying compounds derived from castor oil and for following the course of reactions, monitoring purifications, determining purity and for isolating reaction products. In addition, a silicic acid column liquid partition chromatographic method has been adapted to the separation and analysis of the nonhydroxy, monohydroxy, and dihydroxy acids and methyl esters obtained from castor oil. This procedure, in combination with gas-liquid chromatography of the separated esters, should make possible relatively simple yet accurate determination of the fatty acid composition of castor oils.

B. New and Improved Products

1. Chemical Derivatives. The preparation of amides of hydroxy acids such as ricinoleic acid has been greatly facilitated by the development of a simple, rapid and versatile method of synthesis. Excellent yields (80% or higher) of amides are obtained from mixed carboxylic-carbonic anhydrides and amines. Unlike other methods of activation

of the carboxyl group, the mixed anhydride method does not appreciably affect the hydroxyl function of the hydroxy acids studied. In addition, the mixed anhydrides from castor-derived acids appear quite insensitive to steric hindrance in the amines used. Amides have been prepared using mixed anhydrides from the castor-derived ricinelaidic, 12-hydroxystearic, dihydroxy- and trihydroxystearic acids. Thus far, over twenty new amides have been prepared by this method of synthesis and are being characterized. Several amides are being evaluated, industrially, for use as mold release agents, components of water repellent formulations, etc. Studies are in progress, under contract, to evaluate castor oil-derived monomers for the production of copolymers suitable for industrial use in plastics, etc. Vinyl 12-hydroxystearate has been prepared and its polymerization is being studied. During the preparation of this compound an intermediate was obtained which appears to be an addition compound of vinyl acetate and vinyl hydroxyoleate. This addition compound is readily hydrolyzable to vinyl 12-hydroxystearate or 12-hydroxystearic acid. The contractor has shown that vinyl 12-hydroxystearate may be polymerized in hexane solution using azo-bisisobutyronitrile to initiate polymerization. The polymer was obtained in about 45% yield and was a colorless solid, soluble in tetrahydrofuran, with an inherent viscosity of 0.11 and a softening range of 65 to 75° C. The intermediate (addition compound) polymerized in benzene solution with the same nitrile initiating compound and was converted quantitatively to a polymer which proved to be a tetrahydrofuran-insoluble gel. These studies are being continued and will be extended to other castor oil-derived monomers. Castor oil and certain of its derivatives were tested in rats to elucidate the specific structural configuration responsible for cathartic activity. Results indicate that both the hydroxyl function on carbon 12, and the double bond between carbons 9 and 10 of the ricinoleic acid moiety are essential for cathartic action; this activity is lost upon either masking of the hydroxyl group or hydrogenation of the double bond.

2. Urethane Foams. It has been demonstrated that low-cost polyhydroxy mixtures based on castor oil can form inexpensive, solvent-blown urethane foams. Conditions necessary for the production of strong, uniform, low-density, rigid polyurethane foams using a halomethane (CCl_3F) as a blowing agent were investigated with special emphasis on the use of low-cost castor oil-polyol mixtures (rather than more expensive castor-based derivatives). Castor oil cannot be used alone to make rigid, solvent-blown foams. Excessive shrinkage occurs because of a relatively low ratio of hydroxyl content to molecular weight. One remedy, which was investigated previously, is to modify the castor oil to add more hydroxyl groups, but the process is expensive. An alternate approach, one that keeps the cost down, is to blend the castor oil with inexpensive lower molecular weight polyols to bring the hydroxy-to-weight ratio up. This was done by using solutions of triisopropanolamine and of mixtures of triisopropanolamine and triethanolamine in castor oil as the polyol

components. Foams were prepared by reacting these polyol mixtures, in the presence of catalyst, surfactant and CCl_3F with prepolymers prepared from toluene diisocyanate and certain polyether polyols or mixtures of these polyether polyols with castor oil. The effect of polyol and prepolymer composition, and blowing agent concentration on such foam properties as density and compressive strength was investigated. It was found that compressive strengths are more closely related to urethane group concentration than to cross link site concentration. The properties of castor oil-based foams were also compared with those of the competitive polyether-based foams. A series of foams was prepared in which the polyol portion was varied so that in one case it consisted entirely of a commercial polyether (equiv. wt. 101); in a second case it was a castor oil-triisopropanolamine mixture (equiv. wt. 100); and the third contained an equal mixture of the two polyol types. The castor oil-based foams were slightly stronger and had better dimensional stability after humid aging, but exhibited slightly higher initial shrinkage. The thermal conductivity of the castor oil-based foams increased more rapidly on aging than did the polyether-based foams. Reasons for this phenomenon are being sought, as are means for improving the fire-retardancy of the urethane foams. Such foams can be made self-extinguishing by incorporating, into their formulations, 10 to 20% of certain phosphorous- and halogen-containing compounds. In general, the properties of castor oil-based urethane foams are comparable to those of foams obtained from more costly polyols. In a highly competitive market, these lower cost urethane foam formulations have stimulated considerable industrial interest.

3. Animal Feed Meal. Deallergenized castor meal would constitute a suitable ingredient for livestock and poultry feeds and would, as such, command a considerably higher price than it could as a general purpose agricultural fertilizer. Several methods for deallergenizing the meal are being investigated, including variations of the alkali cooking procedures first used at the Southern Utilization Research and Development Division, New Orleans, Louisiana. The effectiveness of deallergenization treatments is determined most accurately by means of the P.C.A. test (described earlier). Treatment for inactivation of the allergens may be attempted at one or more of several stages of the processing of castor. The most promising stage appears to be immediately following desolventization of the extracted pomace. Preliminary studies indicate that the hull content, moisture level, and particle size of the material all affect the efficiency of treatment. Sufficient treating agent must be used to insure that all of the meal is exposed, but excess moisture will increase drying costs, thus these factors must be balanced carefully. Laboratory-scale treatments tested include: alkaline hydrolysis (sodium, potassium, ammonium, and calcium hydroxides), oxidation, and ammoniation (gaseous). Several such treated samples, notably those treated with sodium and

potassium hydroxide, appeared to have been nearly completely deallergenized. Furthermore, preliminary feeding trials using chicks, indicated that the nutritive value of these treated meals had not been impaired. A series of experiments was conducted to test the value of castor meal as a soybean meal replacement in a chick ration. It was found that, when lysine was added, castor meal could satisfactorily replace 50% of the soybean meal in the ration. At this degree of substitution, the actual level of castor meal in the ration was almost 25%. These experiments offer considerable promise for the development of practical methods for deallergenizing castor meal. However, the laboratory-scale experiments conducted to date will require much modification before economically feasible large-scale processing procedures may be recommended.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Chemical Composition and Physical Properties

Applewhite, T. H., Diamond, M. J., and Goldblatt, L. A. 1961. Chromatostrip Analysis of Fatty Acid Derivatives. J. Am. Oil Chem. Soc., 38, pp. 609-614.

Layton, L. L., DeEds, F., and Moss, L. K. 1960. Fractionation of the Allergenic Proteins of Castor Seed. Federation Proc., 19, Pt. 1, A-195.

Layton, L. L., Lee, S., and DeEds, F. 1961. Use of Old World Monkeys in the Diagnosis of Human Allergy to Castor. Federation Proc., 20, Pt. I, p. 17.

Layton, L. L., Moss, L. K., and DeEds, F. 1961. The Complex Nature of Castor Sensitivity. J. Am. Oil Chem. Soc., 38, p. 76.

Layton, L. L., Dante, B. T., Moss, L. K., Dye, N. H., and DeEds, F. 1961. Electrophoretic Fractionation of Soluble Antigenic Proteins from the Seed of Ricinus Communis (Castor Bean). J. Am. Oil Chem. Soc., 38, P. 405.

Layton, L. L., Lee, S., Dante, B. T., and DeEds, F. 1961. Passive Cutaneous Anaphylaxis in the Detection of Seed Antigens of Ricinus Communis (Castor Bean). J. Am. Oil Chem. Soc., 38, p. 597.

Layton, L. L., Lee, S., and DeEds, F. 1961. Diagnosis of Human Allergy Utilizing Passive Skin-Sensitization in the Monkey, Macaca irus. Proc. Soc. Exp. Biol. and Med., 108, p. 623.

Layton, L. L., Greene, F. S., DeEds, F., and Green, T. W., assisted by E. Yamanaka. 1962. Electrophoretic Fraction of a Carbohydrate-Free Allergenic Preparation from the Seed of the Ricinus Communis (Castor Bean). Am. J. of Hyg., 75, p. 282.

Layton, L. L., Lee, S., Yamanaka, E., Greene, F. S., and Green, T. W. 1962. Allergy Skin Tests Upon Castor Bean Sensitive Humans and Passively Sensitized Cynomolgus Monkeys. Int. Arch. of Allergy and Imm., 20, p. 257.

Layton, L. L., Lee, S., and Yamanaka, E. 1962. Allergen Testing on Monkeys Passively Sensitized by Hay Fever and Asthma Reagins of Human Sera. Nature, 193, p. 988.

Layton, L. L., Yamanaka, E., Lee, S., and Green, T. W. 1962. Multiple Allergies to the Pollen and Seed Antigens of Ricinus Communis. J. Allergy, 33, p. 232.

Layton, L. L., Yamanaka, E., and Denko, C. W. 1962. Demonstrations of Human Reagins to Foods, Cat Dander, An Insect, Ragweed and Grass Pollens. J. Allergy, 33, p. 271.

Layton, L. L., Yamanaka, E., and Greene, F. C. 1962. Use of Monkeys to Demonstrate Allergic Cross-Reactions Among the Euphorbiaceae: Ricinus Communis, Poinsettia Pulcherrima, Euphorbia Esula. J. Allergy, 33, p. 276.

New and Improved Products

Lyon, C. K., Garrett, Vilma H., and Goldblatt, Leo A. 1961. Solvent-Blown Rigid Urethane Foams from Castor-Based Polyols. J. Am. Oil Chem. Soc., 38, pp. 262-266.

Lyon, C. K., Garrett, Vilma H., and Goldblatt, Leo A. 1962. Solvent-Blown Rigid Urethane Foams from Low-Cost Castor Oil-Polyol Mixtures. J. Am. Oil Chem. Soc., 39, pp. 69-71.

III. MARKETING RESEARCH

OILSEEDS AND PEANUTS -- MARKET QUALITY
Market Quality Research Div., AMS

Problem. Harvested oilseeds and peanuts are subject to deterioration in quality and loss in value through insect and fungus damage and contamination, normal metabolic changes, and instability of their oil constituents to atmospheric oxygen. To maintain the quality, more precise information is needed on the biology, ecology, and control of the various species of insects and fungi that attack oilseeds and peanuts; and on the physical and chemical changes and the environmental factors which influence these changes during handling, storage, transportation, and processing. Also, to insure uniform and standardized products in the marketing channels, new and improved methods and techniques for measuring quality factors need to be developed for use in inspection, grading, and standardization procedures.

USDA PROGRAM

The Department has a continuing program involving engineers and chemists engaged in basic and applied research on the quality evaluation, quality maintenance and development of objective methods for quality evaluation of peanuts and soybeans. Research on soybeans is conducted at Washington, D. C.; research on peanuts is done at Raleigh, North Carolina, in cooperation with the North Carolina State College and Federal-State Inspection Service and also by research contract with Texas A & M.

A P.L. 480 grant with the College of Agriculture, Olsztyn, Poland, provides for a study of storage changes in flaxseed. Its duration is 4 years, 1960-1964, and involves P.L. 480 funds with an $18,127 equivalent in Polish zlotys.

The Department also has a continuing long-term program at Tifton, Georgia, involving entomologists engaged in applied research on problems of insect infestation, damage, and contamination of peanuts in the marketing channels. The research is conducted in cooperation with the Georgia Agricultural Experiment Stations, the Agricultural Stabilization and Conservation Service of this Department, growers cooperative associations, and various industry groups.

A continuing program of basic and developmental studies at Savannah, Georgia, involves entomologists and chemists whose research has

cross-commodity application. The entire program is discussed in Area 13. Much of the work on insecticide evaluation and insecticide residue analysis has a direct or indirect relation to peanuts and peanut products. In addition, a portion of the programs on insecticide evaluation and residue analysis have been designated specifically for research on peanut-insect problems.

The Federal scientific effort devoted to research in this area totals 6.3 professional man-years. Of this number 3.5 is devoted to quality evaluation and quality maintenance, and 2.8 to prevention of insect infestation.

A project on the field evaluation of equipment for rapid measurement of oil and moisture content of soybeans was completed.

A research project was completed covering an evaluation of improved equipment and methods for the rapid determination of oil and moisture in soybeans.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 1.2 professional man-years engaged in quality maintenance during storage, and includes: Chemical, biochemical, and physical properties; changes in odor, color, flavor, and nutritive factors affecting the market value of peanuts. The research also includes the relation of microflora to respiration and associated deteriorative changes.

Industry and other organizations also conduct research on oilseeds and peanuts to develop methods for measuring quality factors in edible oils for the purpose of improving their quality control systems, and several peanut processors have cooperated in the malathion testing program by roasting treated peanuts or by making peanut butter, then conducting taste and odor evaluation panel tests to determine whether the treatment had any adverse effect on quality. The estimated annual expenditures are equivalent to approximately 6 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Methods and Equipment for Grading Farmers' Stock Peanuts. Peanut sizers, shellers and splitters developed by this project were used

for all official inspection of farmers' stock peanuts in the United States during the 1961 marketing season. Research work on this project has been directed toward further development of the pneumatic peanut sampler, development of a sample divider for peanuts, design of a cleaner for small samples of farmers' stock peanuts and determination of the effects of various curing treatments on peanut quality. The pneumatic peanut sampler has been approved for use in the official grading of farmers' stock peanuts. The Southeastern Peanut Association has requested that use of either the pneumatic or the spout-type peanut sampler be made mandatory for all official grading of farmers' stock peanuts in the southeastern growing area after the 1962 marketing season. Final development of the pneumatic sampler was completed through a contract agreement with the Georgia Tech Research Institute for the design and testing of the mechanical and structural components of the machine. The Federal-State Inspection Service and the Southeastern Peanut Association also cooperated in the final development, and paid the costs of constructing and testing a prototype model of the sampler. The Fruit and Vegetable Division of the Agricultural Marketing Service cooperated in testing the sampler for accuracy.

A sample divider to draw subsamples from large samples has been developed. The divider is designed to draw a subsample 1/8th the size of the sample in one pass through the divider. The divider was tested in cooperation with the Fruit and Vegetable Division of the Agricultural Marketing Service and was found to draw a representative subsample from samples containing a mixture of sand, hay, rocks, shelled kernels, and peanuts. The divider is to be used on all of the pneumatic peanut samplers to draw a subsample for grading purposes. Further testing is necessary to determine the suitability of the sample divider for use in grading work on other commodities.

A small sample cleaner for farmers' stock peanuts has been designed as the result of a request from the Federal-State Inspection Service and the Southeastern Peanut Association. The cleaner is designed to enable one inspector to determine the percent of foreign material and shelled kernels in a 1000-gram grading sample of farmers' stock peanuts in approximately three minutes. An experimental model of the cleaner has been constructed and will be tested by the Federal-State Inspection Service during the 1962 marketing season.

(MQ 3-29)

2. Evaluation of Damage Factors. Studies to determine the effects of curing treatment on the quality of Virginia-type peanuts have produced the following results: Previous findings were verified that drying rate, independent of temperature, causes peanut kernels to split and skin during the shelling operation while off-flavor is caused by curing temperatures over 95° F. Tests indicated that the hardness of peanut kernels is not appreciably affected either by rate of drying or by curing temperatures. The size of peanut kernels decreases with a decrease in moisture content.

(MQ 3-26)

Studies have been made in Texas to determine the effects of date of harvest and curing treatment on various chemical and organoleptic properties of peanuts. Spanish-type peanuts of the Spantex variety were used in the tests. Preliminary findings from studies on chemical composition follow: (1) Kernel size is better correlated with observed changes in chemical constituents than date of harvest. It appears that kernel size is related to maturity within a given harvest of peanuts, although it is recognized that other factors, such as growing conditions, may affect the size distribution of peanut kernels also. (2) The total pigment level in peanut oil decreases with an increase in kernel size and increases with curing temperature. (3) Peroxide values for extracted oil do not appear to be correlated with kernel size. (4) Crude lipid content increases with kernel size. (5) Total sugar content decreases with an increase in kernel size. (6) Crude protein increases with an increase in kernel size. (7) There does not appear to be any correlation between oleic, linoleic or palmitic acid content and kernel size.

Organoleptic tests which have been completed indicate that size, time of field curing (ripening) and curing temperature affect the flavor of peanuts.

(MQ 3-26)

3. Improved Equipment and Methods for Rapid Measurement of Oil Content of Soybeans. Field testing of the rapid oil testing method and equipment was continued an additional year at Mankato, Minnesota, to provide additional data. A report is in preparation covering 3 years' field testing at Mankato, Minnesota, 2 years at Clarksdale, Mississippi, and 1 year at Decatur, Illinois. Findings indicate that the new method is much more rapid and is as accurate as the standard laboratory method.

(MQ 3-2)

B. Quality maintenance in storage

1. Flaxseed Storage. Under a P.L. 480 grant a study has been initiated of the influence of storage changes in flaxseed on quality of seed and properties of linseed oil. During the first 2 years from 11 to 15 varieties of oil- and fiber-types of flax were studied. Chemical data were obtained on flaxseed grown in various areas; qualitative and quantitative changes during ripening; technological value as related to climate; influence of storage conditions on quality; and effect of temperature and humidity on quality. Preliminary results revealed lipolytic activity of lipases with optimum activity of pH 5 and 8.0 at 37° C. which indicate the presence of two kinds of enzymes. These data and results obtained in subsequent years will be statistically analyzed.

(E21-AMS-6(k)

2. Soybean Oil Storage. Observations at the end of the 3-year period indicate different rates of change in characteristics of soybean oil in storage than in cottonseed oils. Although the once refined soybean oils decrease in color with a linear relationship to time and temperature, the rate of decrease is not dependent on the initial color as was the case of the refined cottonseed oils. Whereas crude cottonseed oils all increased in refined color during the entire storage period (except in the instance of the filtration extracted oil), all of the crude soybean oils decreased in refined color during the first 2 years, but at the end of 3 years there is little further decrease. The crude degummed soybean oils are also following this trend. All of the soybean oils are showing insignificant changes in bleached color and free fatty acids.

The peroxide values of the once refined soybean oils increase at about the same rate as the refined cottonseed oils. The relationship with time-temperature is also linear. Crude soybean oils showed some increase in peroxide value initially and at the end of 3 years showed rapid increase in contrast with crude cottonseed oils which changed little in peroxide value over the entire storage period. The degummed crude soybean oils are following a trend more closely to that of the refined oils.

The data on "dimer" changes and panel evaluations of flavor of soybean oils at the end of 2 years of storage do not definitely indicate any trends or relationships to peroxide value increases during storage.

(MQ 2-44)

C. Prevention of insect infestation

1. Insecticide Evaluation. Beginning in FY 1963 additional research was initiated at Savannah, Georgia, on insecticide evaluation specifically related to the peanut-insect problem. The work is just beginning and there is no progress to report. Other insecticide evaluation work of a cross-commodity nature also has direct or indirect relation to peanuts. It is not feasible to report only certain portions here, or to include all the information under each of the several appropriate commodity areas. Therefore the entire report is included in Area 13.

2. Insecticidal Control. In 1961 large-scale tests on the protection of peanuts against insect infestation were continued in commercial warehouses. Data collected in these studies showed that malathion, properly applied to farmers' stock peanuts as a bulk treatment at load-in, supplemented by periodic surface treatments during storage, effectively controlled insects during the normal storage period. The malathion bulk-plus-surface treatments were more effective, as well as more economical, than synergized pyrethrum applied either as surface or bulk-plus-surface treatments. Chemical residue data obtained during these studies showed that the bulk-plus-surface malathion treatment could be applied to the farmers' stock peanuts without excessive residues resulting on the shelled peanuts. Data obtained from these studies were used by the Food and Drug Administration as a basis for changing the residue tolerance from 8 parts of malathion per million on the whole peanuts to that amount on the kernels only, with shells discarded. It was further demonstrated that the malathion disappeared rapidly during the first month and at a more gradual rate during the remainder of storage.

(MQ 1-14)

Data collected in 1962 from samples of farmers' stock peanuts stored in commercial warehouses confirmed that malathion, properly applied to peanuts by warehousemen at time of load-in and supplemented by periodic surface treatments during storage, effectively controlled insects during the normal storage period. Chemical residue data obtained during this study provided further evidence that residues on shelled peanuts were at a very low level and well within the established tolerances. Peanut oil samples, collected from oil mills processing treated peanuts, have shown that some malathion residues occur in crude oil but only a trace or none in the finished or deodorized refined oil. Peanut butter made from treated peanuts had only a trace or no malathion present. There were no off odors

or flavors reported by the industry as a result of the treatment. It is believed that nearly every warehouseman in the Southeast storing bulk farmers' stock peanuts, whether for himself or under government contract, followed the USDA recommendations for the application of a bulk treatment at the time of load-in. The majority of them used malathion. Insect damage was held to an extremely low level, resulting in extensive savings and a cleaner product for processors and consumers.

(MQ 1-14)

3. Insecticide Residue Analysis. As with insecticide evaluation, the cross-commodity residue analysis work at Savannah, Georgia, is reported in Area 13.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Dickens, James W. 1961. Kernel splitter and inspection belt for peanuts, USDA Marketing Research Report #452, February 1961.

Hart, Joe R. 1961. An investigation of oven methods for determining the moisture content of shelled peanuts, Journal of the American Oil Chemists' Society, XXXVIII (4): 190-194, April 1961.

Dickens, James W. 1962. Shelling equipment for samples of peanuts, Marketing Research Report #528. USDA, AMS, MQRD in coop. with N. C. Agri. Expt. Station.

Dickens, James W. 1962. A new peanut sampler, Issue of Agricultural Marketing.

Dickens, James W. 1962. A peanut sheller for grading samples: An Application of statistics in design, General Edition of the Transactions of the ASAE, 5 (1): 42-45.

Quality Maintenance in Storage

Baumann, Lewis A. 1962. Predicting quality of stored cottonseed oils, USDA Marketing Research Report #523.

Prevention of Insect Infestation

Stored-Product Insects Branch. 1961. Insect prevention and control in farmers' stock peanuts, USDA AMS-453, August 1961, 12 pages.

MARKETING FACILITIES EQUIPMENT AND METHODS
Transportation and Facilities Research Div., AMS

Problem. Differences in varieties of oilseeds and peanuts and in the environments of producing areas where they are conditioned and stored, together with advancing techniques in cultural and harvesting practices, require new or modified marketing facilities, equipment, and methods. Such changes are essential to efficient and economical handling, conditioning, and storing these crops and to maintaining their quality. There is a need for improved designs of facilities based on functional and structural requirements, which will expedite the movement of commodities into, within, and out of the facility. There is also a need for handling and conditioning equipment which will minimize labor and other costs. More knowledge is needed of the relative efficiency of various handling and conditioning methods so that improved or revised methods and equipment can be developed to perform necessary operations.

USDA PROGRAM

The Department has a long-term program involving both applied and basic research as well as application of known principles to the solution of problems of handling, storing, and conditioning field crops in marketing channels. Research on the handling, drying, aerating, and storing of peanuts is conducted at Athens, and Bainbridge, Georgia., in cooperation with the Georgia Agricultural Experiment Stations and with various industry firms. The Federal effort devoted to research in this area totals 2.5 professional man-years to handling, drying, aerating, and storing peanuts; and 1.0 to aeration and storage of cottonseed; and 0.4 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

In 1961 the State Experiment Stations reported no work in this area.

Research by industry in this area directly on oilseeds and peanuts is believed to be of relatively minor importance.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Handling, Drying, Aerating, and Storing Peanuts

1. Handling. A pneumatic conveying system was installed in the research facility at Bainbridge, Ga., and a series of shakedown tests conducted during the 1960 harvest season in which farmers stock peanuts were conveyed vertically. Results of these limited tests were not conclusive but gave some indication of expected performance. For example, certain tests indicated that additional physical damage to the peanuts may run as high as 15 percent when using high air velocities to convey dry (4 to 7 percent moisture) peanuts. Also, that the air velocities required to convey peanuts vertically may not be as high as previously assumed.

Sixty-four tests were run during the 1961 harvest season with lots of farmers stock peanuts having kernel moisture contents ranging from 6 to 13 percent. Air velocities in the 8-inch diameter suction (intake) pipe ranged from 6,300 to 8,700 fpm. The capacity of the test system, for the above tests, ranged between 17 and 27 tons per hour, depending on the air velocity used. Damage to the peanuts increased by as much as 12 percent at the higher velocities--and lower kernel moistures--as they moved through the machine. The speed of the metering valve (for removing peanuts from the cyclone chamber) was also varied to determine optimum operating conditions. Speeds of 48, 62, 70, 80, and 120 RPM were tested. The slowest speed of 48 RPM was determined to be the most desirable. Damage to the peanuts at the higher valve speeds was excessive, as much as 25 percent at 120 RPM as compared to 7 percent at 48 RPM.

The 40-foot bucket elevator at the Bainbridge, Ga., facility was modified in order to test the effects of the methods of loading and discharging, of bucket spacing on the belt, and of belt speed on the volume handled and on the damage occurring to farmers stock peanuts when conveyed by this method. Clear plastic sheets were installed at the loading and discharging points of the buckets in order to record by the use of motion pictures the performance of the buckets during the conveying cycle. Excellent results were obtained by this

method of study. The films showed that the spacing between the bucket path and the edge of the discharge leg of the elevator was too great, allowing an excessive amount of peanuts to fall sown the leg, and that the boot of the elevator had a 6½-inch space between it and the path of the bucket and this space filled with peanuts and remained there until manually cleaned out. Capacity tests were run using this test elevator after being modified to remedy these faults. These tests showed that at the slowest speed of 250 fpm 14.4 tons of peanuts were moved per hour while at a speed of 300 fpm, 13.5 tons per hour were moved. No increase in damage occurred during movement through this system.

A report on "An Improved Dump Pit for Receiving Farmers Stock Peanuts" was completed and published. This report includes plans and specifications for an improved pit having a capacity of 4 tons, almost 3 tons more then the prevailing type of pits now being used. An improved crew organization using a 1-man crew reduces the labor requirements to about 23 percent of that required by the prevailing method using a 2-man crew. Labor costs are reduced $0.44 per 4-ton load received.

2. Aeration. Aeration studies were continued for the two year period in a test system installed in a concrete bin 30 feet in diameter and 111 feet high. This bin was filled in September 1960 with 650 tons of Virginia-type farmers stock peanuts having an average moisture content of 8 percent and an average temperature of 87° F. The lowest average temperature of the peanuts, 46° F., was reached in February 1961 after 812 hours of fan operation at 1/8 cubic feet of air per minute (cfm) per cubic foot of peanuts. The controls permitted the fan to operate only when the relative humidity of the air was 90 percent and above. As a result, the aerated peanuts had a moisture content of 7 percent when shelled in August 1961.

In contrast, comparable nonaerated peanuts from a similar bin had a moisture content of 5 percent when shelled in August. Therefore, it is estimated that the weight loss in a nonaerated bin amounted to some 12 to 13 tons more than in the aerated bin. This added weight of peanuts in the aerated bin had an estimated additional value of at least $1,500. Mainly because of less skin slippage, the aerated peanuts also produced a higher yield of sound mature kernels when shelled than the drier nonaerated peanuts. Results of the tests continued in this test bin in 1961-62 gave comparable results.

Tests also were continued in an aerated flat storage (24' x 120' x 11'). Two hundred and sixty tons of runner-type seed peanuts having an average moisture content of 8 percent and an average temperature of 80° F. were placed in storage during the latter part of September 1960. After 735 hours of aeration, at 1/10 cfm per cubic foot of peanuts (air at 85 to 90 relative humidity and above), the average temperature of the peanuts was reduced to 43° F. and the average moisture content to 6.5 percent. No actual data were obtained on the shelling results of the aerated peanuts. The reduction in moisture content of the peanuts was one to 1½ percent greater in a nonaerated bin, and the warehouseman reported that there was fewer split kernels during the shelling of the aerated peanuts than during the shelling of the nonaerated ones. This storage was filled again in October 1961 with peanuts having an average moisture content of 7.3 percent. The temperature of the peanuts averaged somewhat lower than that for the 1960 test. The fan operating schedule was similar and when shelled in March 1962 the final moisture content of the aerated peanuts was approximately the same as when stored.

3. Drying. The experimental drying unit was completed at Bainbridge, Ga., and several shakedown tests were made during the 1960 harvest season. The unit consists of six drying chambers and two drying (heat and fan) assemblies. The unit permits the reversal of the airflow during drying, the use of different drying air temperatures, the mixing of peanuts during a drying test, and the selection of other conditions for studying methods of drying farmers stock peanuts. The unit also provides facilities for controlling the temperature of the drying air, airflow rate, depth of peanuts to be dried, and the drying rate.

Five shakedown tests were run in the drying unit, using peanuts having initial moisture contents of 16, 14, and 12 percent; drying air temperatures of 105, 110, and 125° F.; and airflow velocities of 27.5 and 90 feet per minute through the peanuts in the drying chambers. Grade analyses were made on the initial and final samples but as these were shakedown tests made to determine the operating characteristics and to make needed changes in the unit, no dried samples were submitted for peanut butter or taste tests. However, no compensation was required because of a lower quality of the dried lots.

In 1961, 28 drying tests were conducted beginning in August and continuing through September. Nine tests were run with Spanish peanuts--6 with a moisture content above 35 percent and 3 with less than 20 percent; 14 with Runner peanuts--5 above 35 percent and 9 with less than 20 percent; and 5 with Virginia peanuts with less than 20 percent. Drying air temperatures of 95, 105, 115, and 125° F. and airflow velocities of 50 and 100 feet per minute were used. The direction of airflow through the peanuts was reversed as needed to prevent the

temperatures of the peanuts in the drying chamber from increasing above 110 to 115° F. for any length of time. The results of these tests were encouraging as no lowering of quality of the dried peanuts was evidenced by official grade factors and limited quality evaluations made on the dried samples showed no lots of "bad" peanuts as a result of the various drying treatments. Additional studies are needed to determine a satisfactory relationship between the maximum temperature of the peanuts during drying, the length of the drying period, the initial moisture content, and peanut variety. Determination of this relationship should provide criteria for developing procedures and equipment for drying capacities desired by commercial dryers.

B. Aeration and Storage of Cottonseed.

At College Station, Tex., studies were initiated to develop and test improved and new methods, techniques, and equipment for handling, conditioning, and maintenance in storage of cottonseed and cottonseed meal. Although aeration systems have been installed in a number of cottonseed storages, both for planting and for processing, only limited research has been done to determine the proper size or capacity of such systems, optimum airflow rates, and the resistance of cottonseed to airflow. Therefore, laboratory tests were initiated to determine the static pressure losses occurring in cottonseed surrounding the aeration duct when air is moved through stored cottonseed.

Static pressure losses measured in cottonseed averaged about 50 percent higher than in grain sorghum. The pressure drop through a 30-inch depth of cottonseed ranged from 0.37 inches of water at a duct surface air velocity of 10 feet per minute to 6.07 inches at 90 feet per minute. Losses through the first 12 inches of cottonseed accounted for about 55 percent of the total losses through the 30-inch depth at all air velocities. When air was moved downward through the cottonseed, air pressure losses in the cottonseed were about 15 percent higher than when air was moved upward. The tests indicated that nonuniformity in the densities of stored cottonseed may be a major problem in providing a reasonably uniform distribution of air during aeration.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Handling, Drying, Aerating and Storing Peanuts.

White, R. A., Jr., and Smith L. L. 1961. An improved Dump Pit for Receiving Farmers Stock Peanuts. Agricultural Marketing Service Report No. 456.

IV. ECONOMIC RESEARCH

ECONOMICS OF MARKETING
Marketing Economics Research Div., ERS

Problem. Most agricultural processing industries are experiencing rapid and drastic changes in their market organization and practices. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economies of scale and efficiencies possible in the marketing of farm products.

Marketing research also is increasingly concerned with evaluating present and prospective programs pertaining to agriculture, such as the Food Stamp Program and Federal Grading Activities and to the changing structure of market industries as this may influence the bargaining power of farmers. Marketing Research also is being directed to the economics of transportation and storage activities of both private firms and Government. Increasing attention is being given to the longer-term outlook for various products and markets as an aid in better assessing the prospects for increasing industrial employment under the Rural Development Program and in assessing prospective inter-regional shifts in the areas of production and marketing for specific products.

USDA PROGRAM

The Department has a continuing long-term program in research to bridge the gap between laboratory developments and commercial adoption so as to fully assist producers to realize more rapidly and more fully benefits of lowered costs, increased returns, and expanded markets that new products and new uses can afford. Research is carried on in industrial and food uses at Washington, D. C., and field offices. The Federal scientific effort devoted to research in this area totals about 24.7 man-years including 4.7 equivalent man-years in contract research. Of this number, approximately 6.9 are engaged in research on oilseeds and peanuts.

Research in the area of marketing margins, costs, and efficiency is designed primarily to provide useful information on the amounts and trends in marketing margins, costs of marketing, labor and equipment requirements, cost standards, economies of scale, and other factors including marketing practices, affecting costs of marketing through all important trade channels and types of firms and for all farm products marketed in commercial volumes. In nearly all studies close cooperation is maintained with industry and trade groups and with individual private firms that generously provide essential data from their records and make their plant facilities available for observation and the conduct of various market tests. Although most of the research is conducted by personnel in Washington, D. C., a considerable part of the work is done by USDA professional staff located at field stations in several states. The USDA scientific effort devoted to research in this area, including cooperative agents paid mainly from Federal funds, total 44.7 professional man-years. Of this number, 4.0 to oilseeds and peanuts.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported no marketing economic studies specifically on oilseeds and peanuts.

The total volume of research in the area of marketing costs, margins and efficiency conducted by private firms and industry groups cannot be estimated accurately, but it undoubtedly is small. In addition, the scope of the problems attacked by private research units is extremely limited. Few agricultural marketing firms are large enough to afford the comparatively high cost of maintaining a competent economic research staff. The few economists working for the larger firms work mainly on special problems of limited scope of special interest to management. In addition, these researchers do not have access to the plants and records of their competitors and their research results rarely are published. Private research institutions conducting research for a private marketing firm usually operate under the same limitations with respect to scope of problems, access to useful data, and publication of results.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Market Potential for New Products and Uses.

Market Potentials for Modified Edible Fats and Oils. Although little change has occurred in the per capita comsumption of fats and oils in the U. S. during the past decade, major shifts have occurred both among

food fat products groups and within groups, as well as important shifts in fats and oils used in end products. These trends have been accelerated by changes in food technology, consumer tastes and regulatory requirements which have led to demands for new and improved fats and oil products for the older markets, as well as intensification of the search for new markets. Utilization research development of new and improved fat and oil products with special properties making them suitable for use in confections, bakery products, food and container coatings, edible lubricants, emulsifiers, coating oils and fats, and other special uses offer an opportunity for opening up entirely new markets for edible fats and oils. A variety of modified fats including a cocoa butter-like fat, dibasic-acid containing fats, and edible polymers and polyester-type derivatives of cottonseed oil are now and will be available to food processors for specialized end uses.

Research has been initiated under contract to appraise the market potentials for edible modified fat products of agricultural origin; to evaluate the competitive situation in relation to price and properties among various modified fats now available and between products of non-agricultural origin in food and container coatings, waxes, and polishes; and to determine the need for improved specialized fat and oil products which would serve as guides for future research and development.

Market Potentials for-Fats in Feeds. Research on potentials for fats in feeds has been completed. Within the span of a few years feed use has developed into the largest single new market for fats and oils. It is predicted that this market will continue to grow in the next 10 years. Increasing numbers of feed manufacturers are adding fats to feeds and feed ingredients. As manufacturers gain experience in adding fats they are using fats in a wider range of products as well as increasing the level of fat added. An important factor in expanded production and increased efficiency in poultry has been the use of high energy rations using added fats in feeds. These and the many other advantages of adding fats to feeds has enabled this to develop into a major market outlet that has stabilized tallow and grease prices, particularly important in view of the displacement on other markets such as soap by synthetic materials. A wide range in kind and grade of fats and oils materials were found to be used with good results. Supply availability most frequently determines kind and grade of fat used.

Market Potentials for Fats and Oils and Fatty Acids in Selected Industrial Use Markets. Technological developments have enabled non-agricultural raw materials to displace agricultural fats and oils and

their fatty acid derivatives in some traditional market outlets, and have reduced their use per unit in other applications. New fats and oils products have been developed, and research is under way to determine their potential for improving the competitive position of agricultural fats and oils. Research is also being conducted to determine requirements for a number of end uses as guides for further physical research to development of properties that will permit fats and oils and their derivatives to meet competition from synthetic materials. Fieldwork was completed during the year. The contractor has prepared drafts of reports in each of six market areas.

Users of fats and oils surveyed often cited pricing and quality of these materials to be paramount problems. Fluctuation of commodity prices discourages long-term investments in plants and processes to utilize these materials, and the inability to make long-term contracts to supply users of derived materials from these fats and oils puts a strong damper on private research toward new product and process developments.

On quality, the inability to obtain stocks of material on a standardized quality basis at all times in the open market, and variations in quality of material with a single description and price created problems for firms seeking or using these materials.

Market Potentials of Unextracted Soybean Meal in Poultry Feeds. Research has been directed at some of the economic questions relative to whole soybean meal. Findings based on a study of the Arkansas poultry area indicate unextracted soybean meal would offer an alternate outlet for soybeans and at the same time afford feed manufacturers and livestock feeders who mix their own feeds an opportunity to have larger amounts of fat in their feeds, without requirement of special fat handling equipment. Inedible tallow and grease are the primary fats being added to formula feeds. The price spread between tallow and grease and soybean oil has been narrowing in recent years, making the processing of cooked, unextracted soybean meal more attractive. In some areas of the United States, production of soybeans and consumption of soybean meal are high, but processing facilities are not locally available. Soybeans are shipped out of these areas and meal is shipped back in. Lowered freight costs on this feed ingredient would amount to a substantial saving. For these reasons cooked, unextracted soybeans may find its most attractive economic position in areas away from the main soybean production and processing areas.

Market Potentials for Fats and Oils in Plasticizers. A special tabulation of fat-derived materials used in plasticizers in 1958 and 1959 was made by the U. S. Tariff Commission to meet industry requests for current data. Consumption of fats and oils in 1959 was about the same as the 72 million pounds reported previously as used in 1957, but total plasticizers use increased from 442 to 524 million pounds. However, new and improved plasticizers from fats and oils increased in use with the increase in total use of plasticizers. The information was reported in the Fats and Oils Situation, November 1960, and reprinted as the Supplement to AMS-382, "The Market Potential for Fats and Oils in Plasticizers."

B. Marketing Costs, Margins and Efficiency.

Preliminary findings of a study on methods of handling farmers stock peanuts indicate that conversion from bag to bulk handling is taking place rapidly. Nearly all peanuts in the Southeast are now handled in bulk, about 50 percent in the Virginia-North Carolina area, but only about 15 percent in the Southwest. Bulk handling reduces labor costs about a third to a half compared with bag handling. Another significant trend affecting efficiency of shelling operations is the decline from 176 plants in 1949 to 99 in 1961 and the corresponding increase in average volume of peanuts shelled per plant. Research on shellers' margins, outturns and related factors is continuing as a means of providing some of the essential information for policy decisions on price differentials for the several types of peanuts under the peanut price support program. Similar research in 1961-62 clearly indicated the direction and magnitude of needed adjustments in differentials for the 4 principal types of farmers stock peanuts under price support programs. A special industry advisory committee considering the problem of differentials followed the research results closely in formulating its recommendations, adopted by the Department, for price differentials for the 1962-63 crop.

Margarine is a major outlet for cottonseed and soybean oils. About 80 percent of all margarine is sold through food stores mainly in 1-pound units. A study completed in 1961 shows that retail prices ranged from 15 to 39 cents a pound and in 1959 averaged 26.5 cents a pound. The farm share of this price was 6.7 cents. In general, prices of highly advertised brands are well above prices of other brands; independent food stores generally charge more for the same brands than do chains. Also, as a rule, the higher the retail price the higher the marketing margin, particularly the margin taken by retailers.

Peanut butter is the primary product made from peanuts. In 1960, retail prices of a 12-ounce jar of peanut butter averaged 41.8 cents of which the grower received an average of 11.8 cents. The gross farm-retail price spread was divided to shellers 2.1 cents, manufacturers 15.0 cents, and wholesalers and retailers 12.9 cents. Margins taken by chainstores averaged 2 cents a jar below margins in other stores and margins on minor brands averaged 8 cents a jar below spreads of major brands. Research is continuing to relate margins to such factors as containers, brands, retail price levels, geographic areas, and types of stores.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Market Potentials for New Products and New Uses.

Doty, Harry O., Jr. September 1961. Fats Added to Feeds - An Economic Analysis. Marketing Research Report No. 489.
Doty, Harry O., Jr. March 1962. Prospects Look Bright for Adding More Fats in Feeds. Agricultural Marketing. (Article).
Hall, Richard. November 1960. Trends in the Consumption of Fats and Oils in Plasticizers. Fats and Oils Situation. (Supplement to AMS-382, The Market Potential for Fats and Oils in Plasticizers).
Hester, O. C. February 20-21, 1961. Future Markets for Cottonseed Oil. Tenth Cottonseed Processing Clinic, New Orleans, Louisiana (Speech).
Poats, F. J., and Sills, Morris W. August 1961. Trends in Industrial Markets for Fats and Oils Derivatives. The Journal of the American Oil Chemists' Society. (Speech).
Poats, F. J. January 26, 1962. Supply and Demand Considerations in the Safflower and Castor Bean Industries. New Crops Conference. University of Nebraska, Lincoln, Nebraska. (Speech).
Trotter, Warren K. February 5-7, 1962. Evaluating the Economics of New Industrial Crops. Marketing Section, Meeting of the Association of Southern Agricultural Workers, Jacksonville, Florida. (Speech).

Marketing Costs, Margins and Efficiency.

Sheller returns and market patterns for major types of peanuts. (Administrative Report on special studies performed at the request of ASCS and representatives of the Peanut Industry.)
The changing market, costs in marketing margarine. 1961. Article in Agricultural Marketing.
Powell, L. A., Sr., 1961. Improved labor utilization at oil mills. Article in Cotton Gin and Oil Mill Press.
Farnworth, V. M. 1961. Returns from marketing cottonseed and soybean oil in margarine. Marketing Research Report No. 503.

COMMODITY SITUATION AND OUTLOOK ANALYSIS
Economics and Statistical Analysis Div., ERS

Problem. Adequate and accurate information is needed on supplies, production and consumption of farm products, and the effects these and other factors have on the prices of agricultural commodities. Such information is needed in planning operations for the producers, processors and distributors and also benefits the consumer in selecting his purchases. Similarly accurate quantitative knowledge of the interrelationships among prices, production and consumption of farm products are needed by Congress and the Administrators of farm programs to effectively evaluate current and future price support and production control programs.

Due to the instability of the prices he receives, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The farmer needs to be provided with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook intelligence and the development of longer range projections of the economic prospects for the principal agricultural commodities.

USDA PROGRAM

This work involves 2.0 professional man-years in Washington. The outlook situation program provides a continuing appraisal of the current and prospective economic situation of fats, oils, and oilseeds. These appraisals are published 5 times a year in the Fats and Oils Situation, quarterly in the Demand and Price Situation, and the National Food Situation. A comprehensive analysis of the fats and oils situation is presented at the Annual Outlook Conference. Special analyses are prepared from time to time on the probable effect of proposed programs on the price, supply, and consumption of fats and oils and their products. Basic statistical series are maintained, improved and published for general use in statistical and economic analysis. A Statistical Handbook, Oilseeds, Fats and Soils, and Their Products is published about every 5 years.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Research of State Experiment Stations in this area is not reported separately but is included with research reported under related areas.

A substantial number of private organizations--including manufacturers of food and fiber products, private commodity analysts, banks and investment houses--are engaged in commodity outlook work similar to that carried on by USDA. This work, however, frequently relates to shorter time periods than those covered by the Department's outlook appraisals; is predominately for private use; and not available to the public. Furthermore, much of the work of the private organizations is heavily dependent on the regular USDA outlook reports and the related statistical material. It is on the whole supplementary to that of the Department, rather than of a competitive or substitute nature. It has been estimated that this type of work in industry and other private organizations is large but no breakdown is available by commodities.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Supplies of food fats and oils during the 1961-62 marketing year totaled a record 15.9 billion pounds (in terms of oil), about 14 percent greater than the year earlier. Total disappearance rose around 11 percent to a new high with record exports accounting for virtually all of the increase as the Food for Peace Program continued to play an important role. But supplies were much larger than total disappearance and a sharp increase in carryover stocks occurred. Most of the increase is attributed to soybeans and butter. Prices received by farmers for 1961 oil-bearing crops averaged slightly above the year before, primarily reflecting higher CCC support levels. Wholesale prices of all fats and oils averaged a little below year earlier levels but oilseed meal prices were somewhat higher.

In addition to the regular analytic work and outlook analyses, considerable time was devoted toward improving statistical techniques used in forecasting and the development of new statistical series. Greater attention was given to our expanding foreign markets and the minor oilseed crops. A special study was made on the planting of minor oilseed crops on diverted acres in 1963. Long-run projections (5 years, by years) are being developed for the food fats and oils as part of a set of ERS projections for the farm economy as a whole. The March 1962 issue of the Fats and Oils Situation marked the 25th anniversary of the publication of this report.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Gazelle, S. A. March 1962. U. S. stockpile of oils gradually reducing. Fats and Oils Situation.

Kromer, G. W. 1962. Fats and Oils Situation. Published 5 times a year. ERS, USDA, Washington, D. C.

Kromer, G. W. January 1962. Use of corn oil in margarine expanding rapidly. Fats and Oils Situation. Reprinted as ERS-52.

Kromer, G. W. May 1962. Soap continues to decline as an outlet for fats and oils. Fats and Oils Situation. Reprinted as ERS-78.

Kromer, G. W. August 1962. Safflower expanding rapidly as oilseed crop. Fats and Oils Situation. Reprinted as ERS-91.

IMPROVING MARKETING OPERATIONS THROUGH RESEARCH WITH FARMER COOPERATIVES

Marketing Division, FCS

Problem. Farmers, in marketing their production, face a revolutionary change in terms of market organization and marketing practices. The ever increasing and important supermarkets requires large quantities, good quality, and frequent delivery which the small farmer, working alone, or a cooperative, or local firm of limited size cannot supply. Cooperatives must find ways to consolidate volume, either through internal growth, mergen, acquisition or federation to help them meet the needs of mass merchandising. Ways must also be found to reduce marketing costs by increasing efficiency through improved operations, better organizations, and more merchanization.

Farmer cooperatives are an important part of the distribution system and represent a major potential for meeting the farmers' marketing problems in the modern distribution system. They are organized and operated to increase farmers' net income. Through cooperatives, farmers seek to increase their bargaining power; obtain needed services at cost; improve the quality of farm products; and obtain a larger share of the consumer's dollar. Cooperatives face many problems in achieving these objectives. Research is needed which will assist marketing cooperatives, as well as other marketing agencies, solve their problems by making available essential factual information and developing practical and useful operating plans and procedures.

USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operations and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms.

The number of Federal professional man-years involved in this work totals 24.8 of which 1.2 are devoted to cooperative marketing of oilseeds and peanuts. The work is centered in Washington, D. C.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

In 1961 the State Experiment Stations reported no work in this area.

The majority of the research work of marketing cooperatives is in the area of merchandising and promotion, although some cooperatives are studying feasibilities of having products graded and packed on the farm. Some farm supply cooperatives have formalized economic research departments, and part of their programs are concerned with the marketing of farm products. A few cooperatives now have employed management consultants to study and advise them on organizational and personnel problems.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

1. Marketing Farmers' Stock Peanuts. To evaluate present and possible alternative methods of marketing farmers' stock peanuts in the Virginia-North Carolina area, studies were made of growers' marketing methods and practices of first-buyers. These studies indicated that peanut-buying is generally a part-time operation, integrated with other services; rapid expansion in efficient bulk handling facilities can be expected; and changes in marketing facilities must reflect the high concentration of small sales per farm and growers' lack of transportation and bulk storage facilities. Because of the shift now taking place toward bulk handling of peanuts, a third phase of this research is examining the economies of size and location for bulk handling facilities. This work is being done under contract with North Carolina State College.

2. Efficiency of Cooperative Soybean Processing. Work is continued with cooperative soybean processors in attempting to improve efficiency, reduce costs and increase returns to farmers. The information is discussed in annual meetings of officials of the cooperatives and has been used as a basis for replying to some 15 requests in the past two years from groups interested in getting into soybean processing.

A central sales agency has been organized and incorporated within the last year. Operational procedures are being worked out including the establishment of an office and hiring of personnel.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

None.

IMPROVEMENT OF CROP AND LIVESTOCK ESTIMATING PROCEDURES
Standards and Research Div., SRS

Problem. Because of limited resources, statistical methods used by the Statistical Reporting Service were devised with a view to producing the most information for the least cost. These methods are subjective in nature and are based largely upon self-selected samples from voluntary crop reporters, who fill out and return mailed questionnaires. The information is generally collected in the form of relatives such as acres this year compared to last, and crop condition as a percentage of full crop. Persistent bias is removed by charting and census or other check data are generally projected to form current estimates. Estimates based on these sample methods have proved relatively satisfactory over the years. However, in seasons when changes are unusually large the changes may not be fully reflected in the appraisals and reports of the respondents to mailed questionnaires. In situations like this, when accuracy is needed most, the estimates may lack the required precision. Then, when the estimates are translated into available supplies, price inequities may occur and, as a result, producers or the processors of oilseeds and peanuts may suffer serious financial loss.

With the development of modern statistics, new methods based upon probability sampling have been developed. Although surveys based upon probability sampling are more expensive to conduct than the traditional self-selecting mailed survey, these new methods offer a means of increasing the precision and reliability of the estimates. A properly designed well-conducted sample survey can produce unbiased estimates which have the desired levels of precision and reliability. Because of the need by the agricultural economy for high quality statistics, it is mandatory that the statistical theory and methods be developed and adapted to the needs of SRS. Some of the new procedures have already been introduced but there is an urgent need for a continuing research to devise efficient survey methods so as to make possible continuing improvement in the quality of SRS statistics.

USDA PROGRAM

The Department conducts a program of applied research designed to strengthen and improve the methodology used in collecting agricultural statistics. The principal disciplines involved are mathematics,

statistics and probability, but other disciplines relating to a particular problem are brought to bear as required. Examples of these are plant physiology, psychology, cartography and photogrammetry. The current program consists of 5.0 professional man-years per year devoted to the study of sample and survey methods and 4.0 professional man-years working on methods for forecasting and estimating yields. Of this total 0.6 professional man-years is engaged in research to improve oilseeds and peanut estimates. Work under this program is done in Washington, D. C., and in SRS field offices located in the States concerned.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

In 1961 the State Experiment Stations reported no work specifically on oilseeds and peanuts.

A number of industries serving agriculture collect information for their use, but this is usually based upon field men's observations and there is no program of related research being conducted. A number of state agencies and a few industry groups cooperate with the Department by supplementing Department resources in order to extend scope or frequency of reports so there is little need for research in crop and livestock estimating methods outside the Department which is independent of the Department's program.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Soybeans. The soybean objective yield studies were continued in 11 North Carolina States and Arkansas in 1961 in 375 sample fields. Difficulties were enccuntered with the model being used to forecast pods. The 1961 crop season was the latest in which data from pilot survey was available. The experimental forecast of pod numbers provided on August 1 by the model currently being tested seriously underestimated the pods at harvest. Additional study is indicated to develop more flexibilility and responsiveness to extreme conditions. Modifications made previously in the forecasting model for the September 1 forecast seem to be working fairly satisfactorily for the group of States as a whole, but parameters are needed for individual states. Part of the difficulty with pod number relationships may be caused by "drilled" fields. Plant spacing in these fields is quite different from fields planted in rows and sampling fluctuations

may obscure or upset relationships. In Arkansas, the crop is so much later than in the North Carolina States that the present early-season forecasting procedure based upon pod counts are not satisfactory. Modification of field procedures has resulted in making fewer counts on the plants in the sample plots and making somewhat more detailed counts on a few plants. These changes in field procedures appear to have reduced counting errors and this should in turn help stabilize relationships.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

None.

V. HUMAN NUTRITION AND CONSUMER-USE RESEARCH

NUTRITION AND CONSUMER-USE RESEARCH

Consumer and Food Economics Research Div.,
and Human Nutrition Research Div., ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help carry out the Department's responsibility to advise on the quantity and variety of foods that will assure maximum benefit and satisfaction to consumers, continuous research is essential on the nutritional requirements of persons of all age groups, and on the nutrient and other inherent values of foods and how to conserve or enhance these values in household preparation and processing. Periodic examinations of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective nutrition education. Such information provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and use.

USDA PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition education programs.

The research is carried out by two Divisions of the Agricultural Research Service-- The Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done in Washington, D. C.,

and at Beltsville, Md.; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas totals 61.1 man-years. It is estimated that approximately 3.2 is concerned with studies related to oilseeds and peanuts.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and micro-organisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. This basic nutrition research is described on a nutrient basis in the report for the Food and Nutrition Advisory Committee. The total Federal effort is 29.5 professional man-years.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations research in 1961 included 22.4 professional man-years devoted to studies of the inherent properties of foods and of their household use; 17.6 to analyses of a variety of foods for vitamins, various lipid and protein components, and minerals; and 2.7 to studies of food consumption and dietary levels of households and of food management practices. Although the State work has not been reported on a commodity basis, some of the above research is applicable to this report.

Industry and other organizations such as universities and professional organizations are estimated to devote about 36 man-years to research on the preparation of materials for nutrition education, surveys of diets of individuals, and studies of functional properties and stability of food and of their specific nutrient contents. Limited work is done on the amount and structure of nutrients in foods and on compiling food composition data. Again, some of this work is applicable to this report.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Nutritive Values of Foods.

1. Tables of Food Composition. Data review has been completed for a revised edition of Agriculture Handbook No. 8, "Composition of Foods...Raw, Processed, Prepared." This edition will have nearly 2,500

food items as compared with 751 items of the preceding edition, and upwards of 45,000 separate compositional values. For many foods, data will be provided for different forms--raw, cooked, canned, frozen, milled, dried, instant, dietetic, etc. The new publication will have, in addition to other constituents, data for protein, fat, carbohydrate, five vitamins (vitamin A, niacin, riboflavin, thiamine, ascorbic acid), six minerals (calcium, phosphorus, iron, sodium, potassium, magnesium). Explanatory notes for foods and nutrients will be added for users of the tables. Information on cholesterol and fatty acids will also be included.

Ten oilseeds and peanuts will be included in the nearly completed revision of Handbook 8. With their various products, the total number of items in this category will be about 60. This will include 3 classes of peanut butter with different amounts of added ingredients, peanut spread, 17 salad dressings, and 22 soybean products.

2. Vitamin Analyses. Values more representative of the vitamin B_6 content of foods now may be obtained by use of a method recently developed at Beltsville, Maryland. Separation by column chromatography of the three forms of vitamin B_6 naturally occurring in foods permit each form to be assayed individually. Values derived from these data for total vitamin B_6 approximate closely values obtained from rat bioassay.

3. Fatty Acids. Adaption of gas-liquid chromatography methods has made possible the identification and determination of 26 fatty acids in food fats and oils and in fats and oils extracted from food samples. Work is continuing on the improvement of the method.

Peanuts and oil seeds. Analyses are in progress on the fatty acid composition of processed oils, including cottonseed, soybean, corn and olive oils, on several shortenings and hydrogenated shortening.

B. Food Properties Related to Quality and Consumer Use.

Oilseeds and Peanuts. The allowable range of fat to other ingredients for good quality baked products is being determined as a basis for recommending how different types and amounts of fats can be used in home food preparation. Corn oil, cottonseed oil, soybean oil, lard and two hydrogenated vegetable fats were evaluated as shortening agents in pastry and in baking powder biscuits. Oils were more efficient shortening agents in pastry and solid fats in baking powder biscuits.

Oil pastry was nearest optimum in quality at the 45 percent level by weight of fat to flour and solid-fat pastry at the 51 percent level of added fat. In baking power biscuits, a level of fat between 25 and 38 percent was optimum for all six fats.

Investigation of the shortening properties of corn oil, hydrogenated vegetable fat, lard and butter at different levels of added fat in cakes and muffins is in progress. Sensory, physical and chemical measurements are being used to determine the influence of the proportion and kind of fat on the quality of the baked product.

C. Food Economics and Diet Appraisal.

1. Food Consumption and Dietary Levels. Information on the nutritive value of the food consumption of households based on the 1955 survey data has been summarized in Report No. 16 of the 1955 Household Food Consumption Survey series. Average family food supplies for a week in 1955 were sufficient to provide more than the National Research Council's recommended allowances for calories and eight nutrients for which values were calculated. However, many households (48 percent) had diets that did not fully meet the allowances in one or more nutrients. Other analyses of survey data show the relation of family size, the education of the homemaker, and of income to the food consumption of households. Because of interest in information on quantities of foods used by high consumers as well as average consumers estimates were made for some 60 food items of the ninth decile--the figure dividing the highest 10 percent of the consumers from the lowest 90 percent. For the major food groups the amount consumed per person in "high consumption" households was 1.5 to 3.5 times as much as in "average consumption" households.

Two surveys were conducted cooperatively with the Marketing Research Division, Economic Research Service in Detroit, Michigan, and Fayette County, Pennsylvania, to provide evidence on the extent to which food consumption is increased and diets improved as a result of the Food Stamp Program.

A report of the food consumption and dietary levels of a group of older, low-income households in Rochester, New York, is in preparation.

Work is being undertaken on food consumption and nutritive content of diets of individuals. A systematic review and summarization of quantities of food consumed is being made through a cooperative

agreement with the Minnesota Agricultural Experiment Station. A similar review of the nutritive content of the diets of individuals is being made by Washington staff.

The nutrient content of the per capita food supply, calculated each year, using data on retail weight quantities of food as developed by the Economic Research Service, provides the only source information on year-to-year changes from 1909 to date.

2. Food Management Practices. Information on the kinds, amount, and nutritive value of foods used and discarded in households has been obtained in a series of small studies. Results will help to evaluate survey data on household food consumption.

A report on household practices in handling and storing of frozen food has been prepared, based on surveys in Baltimore, Maryland, and Indianapolis, Indiana. Households provided information on the length of time frozen food was held in home storage, and the temperature of the compartment in which frozen food was being held at the time of the interview.

3. Development of Food Budgets and Other Basic Data for Food and Nutrition Programs. An important aspect of nutrition research is the interpretation and application of research findings to practical problems of food selection in relation to health. An ongoing program of work includes assembling and interpreting available information on nutritional needs, food consumption, and nutritional value of foods for use by nutritionists, teachers, health workers, and other leaders concerned with nutrition education programs.

A technical report explaining the development of the food budgets, "Family Food Plans and Food Costs," has been completed and is in press. Another in the series of popular publications on food management has been prepared, "Food for the Young Couple." A publication "Family Food Budgeting...for good meals and good nutrition," designed to help families of all sizes is also being prepared.

Regular pricing of family low-cost, moderate-cost, and liberal food plans is published in Family Economics Review on a quarterly basis for the U. S. average and on an annual basis for the regions and the low-cost food plan for the South. Each plan gives suggested quantities of food that will meet nutritional needs for each of 17 age and sex groups and for women during pregnancy and lactation so that household or population totals may be obtained.

Nutrition Committee News, a bimonthly periodical prepared for members of State nutrition committees and other workers in nutrition education provides a channel for disseminating pertinent information and for reporting nutrition education activities. A Nutrition Education Conference sponsored jointly by USDA through its Nutrition Programs Service and by the Interagency Committee on Nutrition Education was held in Washington, D. C., January 29-31, 1962.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Nutritive Value of Foods.

Consumer and Food Economics Research Division. 1960. Nutritive value of foods. Home and Garden Bul. 72, 30 pp.

Lichtenstein, H., Beloian, A., and Murphy, E. W. 1961. Vitamin B_{12}--microbiological assay methods and distribution in selected foods. Home Econ. Res. Rpt. 13, 15 pp.

Hopkins, H. T., Murphy, E. W., and Smith, D. P. 1961. Minerals and proximate composition of organ meats. J. Amer. Diet. Assn. 38, pp. 344-349.

Food Consumption and Dietary Levels.

LeBovit, C., Cofer, E., Murray, J., and Clark, F. 1961. Dietary evaluation of food used in households in the United States. Household Food Consumption Survey 1955, Rpt. No. 16. 55 pp.

Consumer and Food Economics Research Division. 1961. Data on high and average food consumption per person. Radiological Health. 2(3): 119-122.

Reese, R. B. and Adelson, S. F. 1962. Food consumption and dietary levels under the pilot food stamp program, Detroit, Michigan, and Fayette County, Pennsylvania. Agr. Econ. Rpt. No. 9.

Adelson, S. F. 1961. Practical procedures for dietary surveys. Proc. 3rd International Congress of Dietetics. pp. 158-163.

Nutritive Value of National Food Supply.

Consumer and Food Economics Research Division. 1961. Nutrients available for consumption per capita per day, 1909-1960. Supplement for 1960 to Agr. Handbook 62, Consumption of food in the U. S. pp. 43-44.

Consumer and Food Economics Research Division. 1961. Nutrients available for consumption per capita per day 1935-39 and 1947-49. Averages, 1959, 1960, and preliminary estimates for 1961. Table 4, Nat. Food Sit. Nov. p. 20.

Food Management Practices.

Adelson, S. F., Asp, E., and Noble, I. 1961. Household records of foods used and discarded--a pilot study in St. Paul. Journ. Amer. Dietet. Assn. 39(6); 578-584.

Development of Food Budgets and Other Basic Data for Food and Nutrition Programs.

Consumer and Food Economics Research Division. Estimated cost of 1 week's food. In Family Economics Review, ARS-62-5. (USA average issued quarterly, estimated for four regions issued annually.)
Consumer and Food Economics Research Division. 1960. Food and your weight. Home and Garden Bul. 74. 30 pp.
Consumer and Food Economics Research Division. 1962. Proc. of nutrition education conference, Jan. 29-31, 1962. Misc. Pub. 913. (In press.)
Nutrition committee news (periodical, 6 issues):
July-Aug. 1961, Sept.-Oct.1961, Nov.-Dec. 1961, Jan.-Feb. 1962, Mar.-Apr. 1962, May-June 1962.